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JIGS AND FIXTURES

By EINAR MORIN

PART II

DRILL JIGS

SECOND EDITION

CONTENTS

JIGS AND FIXTURES—PART II

CHAPTER V

DESIGN OF OPEN DRILL JIGS*

To give any rational rules or methods for the design of drill jigs would be almost impossible, as almost every jig must be designed in a somewhat different way from every other jig, to suit and conform to the requirements of the work. All that can be done is to lay down the principles. The main principles for jigs as well as fixtures were treated at length in Chapter I. It is proposed in the following to dwell more in detail on the carrying out of the actual work of designing jigs.

Before making any attempt to put the lay-out of the jig on paper, the designer should carefully consider what the jig will be required to do, the limits of accuracy, etc., and to form, in his imagination, a certain idea of the kind of a jig that would be suitable for the purpose. In doing so, if a model or sample of the work to be made is at hand, it will be found to be a great help to study the actual model. If the drawing, as is most often the case, is the only thing that is at hand, then the outline of the work should be drawn in red ink on the drawing paper, on which the jig is subsequently to be laid out, and the jig built up, so to speak, around this outline. The designing of the jig will be greatly simplified by doing this, as the relation between the work and the jig will always be plainly before the eyes of the designer, and it will be more easily decided where the locating points and clamping arrangements may be properly placed. When drawing and projecting the different views of the jig on the paper, the red outline of the work will not in any way interfere, and when the jig is made from the drawing, the red lines are simply ignored, except to the extent to which the outline of the pieces may help the tool-maker to understand the drawing and the purpose of certain locating points and clamping devices.

If it is possible, the jig should be drawn full size, as it is a great deal easier to get the correct proportions, when so doing. Of course, in many cases, it will be impossible to draw the jigs full size. In such cases the only thing to do is to draw them to the largest possible regular scale. Every jig draftsman should be supplied with a set of blue-prints containing dimensions of standard screws, bolts, nuts, thumb-screws, washers, wing nuts, sliding points, drills, counter-bores, reamers, bushings, etc.; in short, with blue-prints giving dimensions of all parts that are used in the construction of jigs, and

* MACHINERY, August and September, 1908.

which are, or can be, standardized. It should be required of every designer and draftsman that he use these standards to the largest possible extent, so as to bring the cost of jigs down to as low a figure as possible.

If it does not meet with objections from higher authorities, which it ought not to, it is highly advantageous for the obtaining of best results, that, before starting on the drawing, the draftsman who is to lay out the jig should converse with the foreman who is actually going to use the jig. Oftentimes this man will be able to supply the best idea for the making of the jig or tool. Not only is advantage taken of the combined experience of the draftsman and the foreman, but it is also a precaution of great importance for making all parties feel satisfied.

As a jig drawing, in most cases, is only used once, or at most only a very few times, it is not considered worth while to make a tracing or blue-print from the drawing, but, as a rule, the pencil drawing itself may be used to advantage. If, however, it is given out in the shop directly as it comes from the drawing-board, it is likely to get soiled, and to be used in such a manner that, after a while, it would be impossible to make out the meaning of the views shown on it. For this reason, in the first place, jig drawings should be made on heavy paper, preferably of brown color, which is not as quickly soiled as white paper. In order to prevent the drawing being torn, it should be mounted on strawboard, and held down along the edges by thin wooden strips, nailed to the board. It is also desirable to cover the drawings with a thin coat of shellac before they are sent out in the shop. When this is done, the dirt and black spots which will be always found on the drawing when it stays in the shop, if only for a few hours, may be washed off directly; and the shellac itself may be washed off by wood alcohol, when the drawing is returned to the drafting-room. The drawing, after having been cleaned, is then detached from the strawboard, which may be used over and over again. The drawing is, of course, filed away according to the drafting-room system. The most advantageous sizes for jig drawings for medium to heavy work are as follows:

Full size sheet, $40 \times 27\frac{1}{2}$ inches.
Half size sheet, $27\frac{1}{2} \times 20$ inches.
Quarter size sheet, $20 \times 13\frac{3}{4}$ inches.
Eighth size sheet, $13\frac{3}{4} \times 10$ inches.

Of course, these sizes will vary in different shops, and in many cases, particularly when the tool designing department and the regular drafting-room are combined as one drafting department, the jig drawings should be of the same regular sizes as the ordinary machine drawings.

It is common in a great many shops to make no detailed drawings of jigs, but simply to draw a sufficient number of different views and sections, and to dimension the different parts directly on the assembly drawings. In cases where the jig drawings are extremely complicated, and where they are covered with a large number of dimensions which

make it hard to read the drawing and to see the outlines of the jig body itself, it has proved a great help to trace the outlines of the jig body, and of such portions as are made of cast iron, on tracing paper, omitting all loose parts, and simply putting on the necessary dimensions for making the patterns. A blue-print is then made from this paper tracing, and this is sent to the pattern-maker, who will find the drawing less of a puzzle, and who will need to spend far less time to understand how the pattern actually looks. A less skilled, and consequently a cheaper, man may also be used for making the pattern. It is, however, greatly to be doubted whether it is good policy not to detail jig drawings completely, the same as other machine details.

When jigs are made up for pieces of work which require a great many operations to be carried out with the same jig, and where a great number of different bushings, different sizes of drills, reamers, counterbores, etc., are used, a special operation sheet should be provided which should be delivered to the man using the jig, together with the jig itself. This enables him to use the jig to best advantage. On this sheet should be marked the order in which the various operations are to be performed, and the tools and bushings which are to be used. Of course, the bushings in such a case should be numbered or marked in some way so as to facilitate the selection of the correct bushing for the particular tool with which it is used. If this system is put in force and used for simpler classes of jigs also, the operator will need few or no instructions from his foreman, outside of this operation sheet.

The Designing of Open Jigs

The present chapter will be devoted to explaining and illustrating the application of the principles previously outlined, to the simplest and most common design of drill jig—the open jig. We will assume that the drill jig is to be designed for a piece of work, as shown in Fig. 61. Consideration must first be given to the size of the piece, to the finish given to the piece previous to the drilling operation, the accuracy required as regards the relation of one hole to the other, and in regard to the surfaces of the piece itself. The number of duplicate pieces to be drilled must also be considered, and, in some cases, the material.

The very simplest kind of drill jig that could be used for the case taken as an example would be the one illustrated in Fig. 62, which simply consists of a flat plate of uniform thickness of the same outline as the piece to be drilled, and provided with holes for guiding the drill. Such a jig would be termed a jig plate. For small pieces, the jig plate would be made of machine steel and case-hardened, or from tool steel and hardened. For larger work, a machine steel plate can also be used, but in order to avoid the difficulties which naturally would arise from hardening a large plate, the holes are simply bored larger than the required size of drill, and are provided with lining bushings to guide the drill, as shown in Fig. 63. It would not be

necessary, however, to have the jig plate made out of steel for large work, as a cast-iron plate provided with tool steel or machine steel guiding bushings would answer the purpose just as well, and at the same time be much cheaper, and almost as durable. The thickness of the jig plate varies according to the size of the holes to be drilled and the size of the plate itself.

The holes in the jig in Fig. 62 and in the bushings in the jig in Fig. 63, are made the same size as the size of the hole to be drilled in the work, with proper clearance for the cutting tools. If the size and location of the holes to be drilled are not of great consequence, it is sufficient to simply drill through the work with a full size drill guided by the jig plate, but when a nice, smooth, standard size hole is required, the holes in the work must be reamed. The hole is first spotted by a spotting drill, which is of exactly the same size as the reamer used for finishing, and which fits the hole in the jig plate or bushing nicely. Then a so-called reamer drill, which is 0.010 inch, or less, smaller in diameter than the reamer, is put through, leaving only a slight amount of stock for the reamer to remove, thereby obtaining a very satisfactory hole. Sometimes a separate loose bushing is used for each one of these operations, but this is expensive and also unnecessary, as the method described gives equally good results.

By using the rose reaming method very good results will also be obtained. In this case two loose bushings besides the lining bushing will be used. These bushings were described and tabulated in Chapter II. The drill preceding the rose chucking reamer is 1/16 inch smaller than the size of the hole. This drill is first put through the work, a loose drill bushing made of steel being used for guiding the drill. Then the rose chucking reamer is employed, using, if the hole in the jig be large, a loose bushing made of cast iron.

When dimensioning the jig on the drawing, dimensions should always be given from two finished surfaces of the jig to the center of the holes, or at least to the more important ones. In regard to the holes, it is not sufficient to give only the right angle dimensions, *a*, *b*, *c*, and *d*, etc., Fig. 62, but the radii between the various holes must also be given. If there are more than two holes, the radii should always be given between the nearest holes and also between the holes standing in a certain relation to one another, as, for instance, between centers of shafts carrying meshing gears, sprockets, etc. This will prove a great help to the tool-maker. In the case under consideration, the dimensions ought to be given from two finished sides of the work to the centers of the holes, and also the dimension between the centers of the holes to be drilled.

When using a simple jig, made as outlined in Figs. 62 and 63, this jig is simply laid down flat on the work and held against it by a C-clamp, a wooden clamp, or, if convenient, held right on the drill press table by means of a strap or clamp, as shown in Fig. 64. Here two pieces of the work are shown beneath the jig plate, both being drilled at one time.

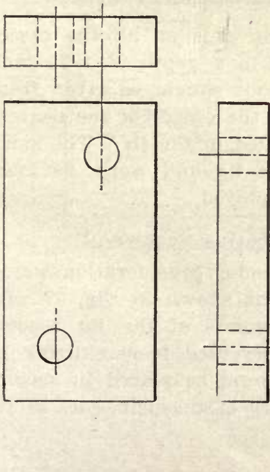


Fig. 61. Sketch of Plate to be Drilled

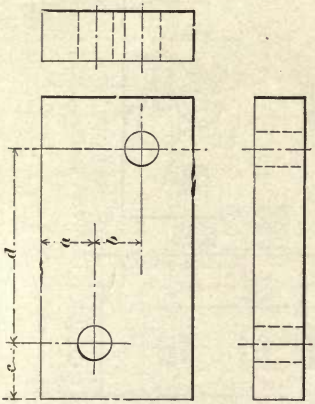


Fig. 62. Simplest Form of Jig for Piece shown in Fig. 61

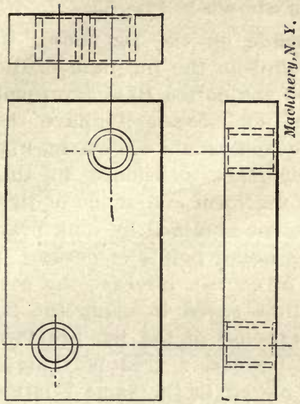


Fig. 63. Plate Jig with Inserted Guide Bushings

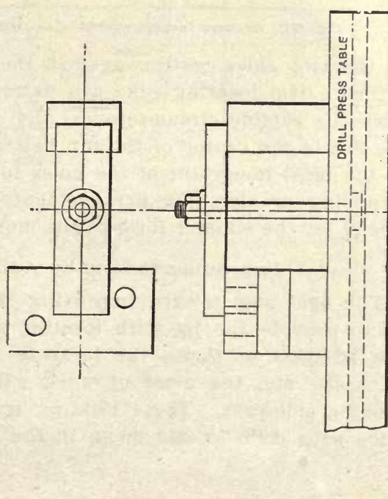


Fig. 64. Holding Jig and Work on Drill Press Table. Two Pieces Drilled at Once

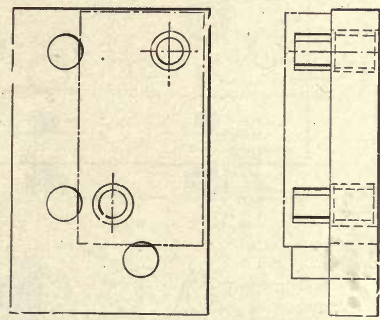


Fig. 65. First Improvement on Plate Jig; Locating Pins Inserted

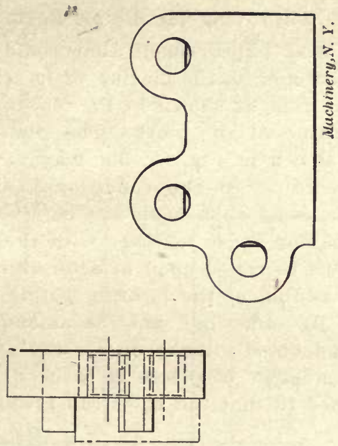


Fig. 66. Variation in Shape of Plate Jig

Improving the Simple Form of Jig Shown in Fig. 63

The first improvement that could be made on the jig shown in Fig. 63 would be the placing of locating points in the jig plate in the form of pins, as shown in Fig. 65, in which the dotted lines represent the outline of the work. The plate need not necessarily have the shape shown in Fig. 65, but may have the appearance shown in Fig. 66, according to the conditions. As previously mentioned in this chapter, exact rules could not be given for the form and shape of jigs, but common sense together with the judgment obtained by long practice must be relied upon in determining the minor points of design.

The adding of the locating points will, of course, increase the cost of the jig somewhat, but the amount of time saved in using the jig will undoubtedly make up for the added expense of the jig, provided a fair number of pieces is to be drilled; besides, a great advantage is gained in that the holes can always be placed in the same relation

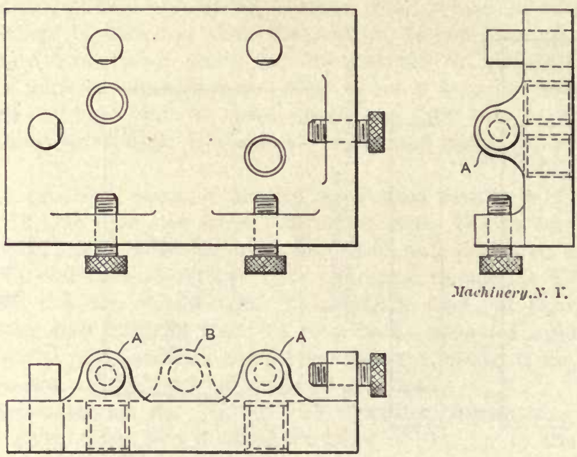


Fig. 67. Second Improvement: Locating Screws Holding Work in Place

to the two sides resting against the locating pins on all the pieces drilled. The locating pins are flattened off to a depth of 1/16 inch from the outside circumference, and dimensions should be given from the flat to the center of the pin holes and to the center of the nearest or the most important of the holes to be drilled in the jig. The same strapping or clamping arrangements for the jig and work, as mentioned for the simpler form of jig, may be employed.

Improving the Jig by Adding Locating Screws

The next step toward improving the jig under consideration would be to provide the jig with locating screws, as shown in Fig. 67. By the addition of these, the locating arrangements of the jig become complete, and the piece of work will be prevented from shifting or moving sideways. These locating screws should be placed in accordance with Rule 10 laid down in the summary of the principles of jig

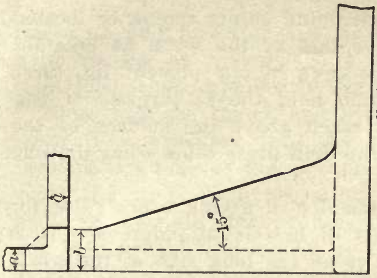


Fig. 69. Design of Legs for Cast-iron Jig Bodies

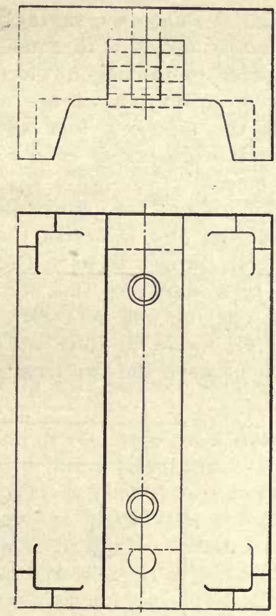
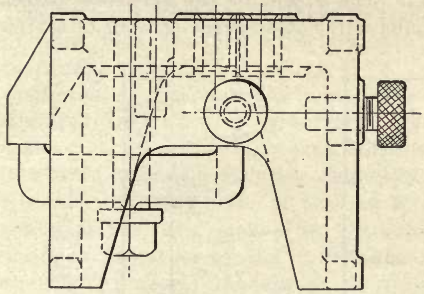


Fig. 70. Form of Jig which may be Used for Drilling a Number of Pieces Simultaneously



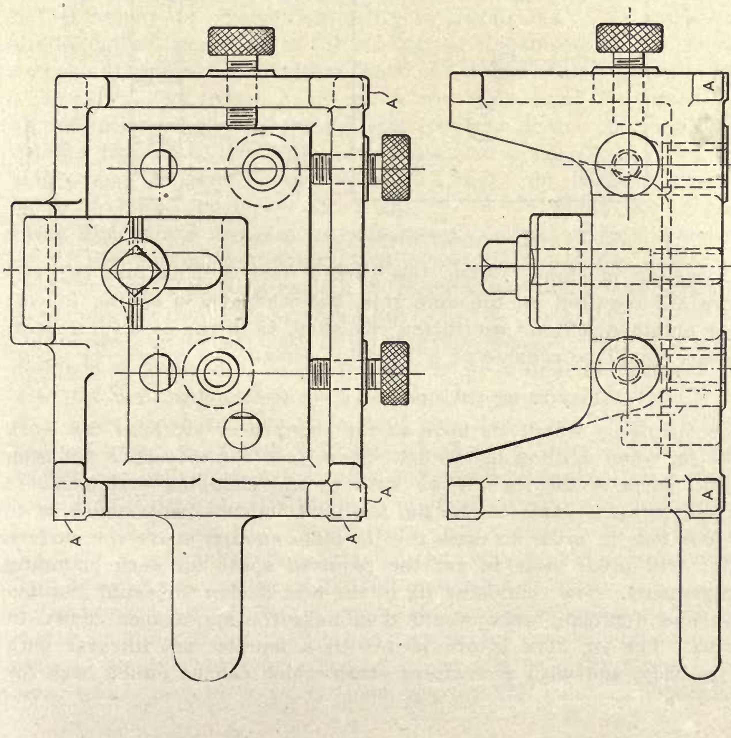


Fig. 68. Complete Jig for Rapid Duplicate Work

design in Chapter I, saying that all clamping points should be located as nearly opposite to some bearing points of the work as possible. In order to provide for locating set-screws in our present jig, three lugs or projections *A* are added which hold the set-screws. If possible the set-screw lugs should not reach above the surface of the piece of work, which should rest on the drill press table when drilling the holes.

The present case illustrates the difficulty of giving exact rules for jig design and indicates the necessity of individual judgment. It is perfectly proper to have two set-screws on the long side of the work, but in a case like this where the piece is comparatively short and stiff, one lug and set-screw, as indicated by the dotted lines at *B* in Fig. 67, would be fully sufficient. The strain of the set-screw placed right between the two locating pins will not be great enough to spring

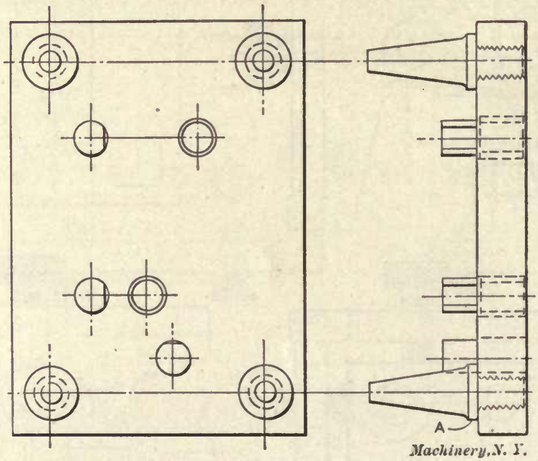


Fig. 71. Legs Screwed into Jig Body

the piece out of shape. When the work is long and narrow, two set-screws are required on the long side, but whenever a saving in cost can be obtained without sacrificing efficiency, as in the case illustrated, two lugs would be considered a wasteful design.

Providing Clamps and Feet for the Jig

The means by which we have so far clamped or strapped the work to the jig when drilling in the drill press (see Fig. 64) have not been integral parts of the jig. If we wish to add clamping arrangements that are integral parts of the jig, the next improvement would be to add four legs in order to raise the jig plate enough above the surface of the drill press table to get the required space for such clamping arrangements. The completed jig of the best design for rapid manipulation and duplicate work would then have the appearance shown in Fig. 68. The jig here is provided with a handle cast integral with the jig body, and with a clamping strap which can be pulled back for

removing and inserting the work. Instead of having the legs solid with the jig, as shown in Fig. 68, loose legs, screwed in place, are sometimes used, as shown in Fig. 71.

These legs are round, and provided with a shoulder *A*, preventing them from screwing into the jig plate. A headless screw or pin through the edge of the circumference of the threads at the top prevents the studs from becoming loose. These loose legs are usually made of machine steel or tool steel, the bottom end being hardened and then ground and lapped, so that all the four legs are of the same length. It is the practice of many tool-makers not to thread the legs into the jig body, but simply to provide a plain surface on the end of the leg, which enters into the jig plate, and is driven into place. This is much easier, and there is no reason why for almost all kinds of work, jigs provided with legs attached in this manner should not be equally durable.

Of course, when jigs are made of machine or tool steel, and legs are required, the only way to provide them is to insert loose legs. In the case of cast-iron jigs, however, solid legs cast in place are preferable. The solid legs cast in place generally have the appearance shown in Fig. 69. The two webs of the leg form a right angle, which, for all practical purposes, makes the leg fully as strong as if it were made solid, as indicated by the dotted line in the upper view. The side of the leg is tapered 15 degrees, as a rule, as shown in the engraving, but this may be varied according to conditions. The thickness of the leg varies according to the size of the jig, the weight of the work, and the pressure of the cutting tools, and depends also upon the length of the leg. The length *b* on top is generally made 1½ times *a*. As an indication of the size of the legs required, it may be said that for smaller jigs, up to jigs with a face area of 6 square inches, the dimension *a* may be made from 5/16 to 3/8 inch; for medium sized jigs, ½ to ⅝ inch; for larger sized jigs, ¾ to 1½ inch; but of course, these dimensions are simply indications of the required dimensions. As to the length of the legs, the governing condition, evidently, is that they must be long enough to reach below the lowest part of the work and the clamping arrangement.

If a drill is to be used in a multiple spindle drill, it should be designed a great deal stronger than it is ordinarily designed when used for drilling one hole at a time. This is especially true if there is a large number of holes to drill simultaneously. The writer has had sad experiences with drill jigs which would give excellent service in common drill presses for years, but which, when put on a multiple spindle drill, immediately broke to pieces as if subjected to a hammer-blow. It is evident that the pressure upon the jig in a multiple spindle drill is as many times greater than the pressure in a common drill press as the number of drills in operation at once.

Referring again to Fig. 68, attention should be called to the small lugs *A* on the sides of the jig body which are cast in place for laying out and planing purposes. The handle should be made about 4 inches long, which permits a fairly good grip by the hand. The design of

the jig shown in Fig. 68 is simple, and fills all requirements necessary for producing work quickly and accurately. At the same time, it is strongly and rigidly designed. Locating points of a different kind from those shown can, of course, be used; and the requirements may be such that adjustable locating points, as described in Chapter III, may be required. A more quick acting, but at the same time, a far more complicated clamping arrangement might be used, but the question is whether the added increase in the rapidity of manipulation offsets the expense thus incurred.

Another improvement which should not be overlooked, and which in a case like this probably could be made, and which it is always wise to look into at any rate is: Can more than one piece be drilled at one time? In the present case, the locating pins can be made longer, or, if there is a locating wall, it can be made higher, the legs of the jig can be made longer, and the screw holding the clamp can also

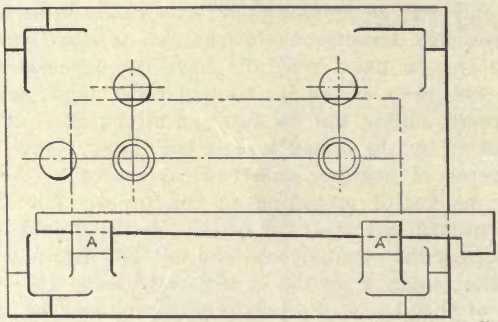


Fig. 72. Jig with Wedge for Holding the Work

be increased in length; if the pieces of work are thick enough, set-screws for holding the work against the locating pins can be placed in a vertical line, or if the pieces be narrow, they can be placed diagonally, so as to gain space. If the pieces are very thin, the locating might be a more difficult proposition. If they are made of a uniform width, they could simply be put in the slot in the bottom of the jig, as shown in Fig. 70, or if a jig on the principles of the one shown in Fig. 68, is used, they might be located sideways by a wedge, as shown in Fig. 72. A couple of lugs *A* would then be added to hold the wedge in place, and take the thrust. In both cases the pieces must be pushed up in place endways by hand. If the pieces are not of exactly uniform size, and it is desired to drill a number at a time, they must be pushed up against the locating pins by hand from two sides, and the clamping strap must be depended upon to clamp them down against the pressure of the cut, and at the same time prevent them from moving side or endwise. If the accuracy of the location of the holes is important, but one piece at a time should be drilled.

CHAPTER VI

EXAMPLES OF OPEN DRILL JIGS*

A typical example of an open drill jig, very similar to the one developed and explained in the previous chapter, is shown in Fig. 73. The work is located against the three locating pins *A*, and held in place against these pins by the three set-screws *B*. The three straps *C* hold the work securely against the finished pad, in the bottom of the jig. These clamps are so placed that when the work has been drilled and the clamp screws loosened, the clamps will swing around a quarter of a turn, allowing the work to be lifted directly from the jig and a new piece of work inserted; then the clamps are again turned around into the clamping position, and the screws tightened. These

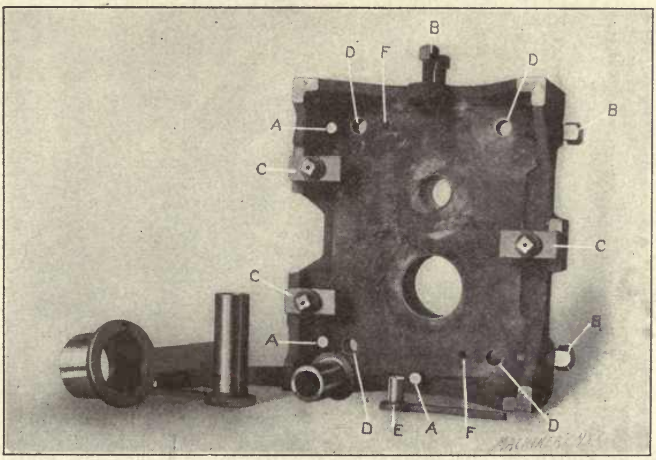


Fig. 73. Example of Open Drill Jig. View showing Front Side

straps are integral parts of the jig; at the same time, they are quickly and easily manipulated, and do not interfere with the rapid removal and insertion of the work. The strength and rigidity of the feet in proportion to the jig should be noted, this strength being obtained by giving proper shape to the feet, without using an unnecessary quantity of metal.

The jig in Fig. 73 is also designed to accommodate the component part of the work when it is being drilled. When this is done, the work is held on the back side of the jig, shown in Fig. 74. This side is also provided with feet, and has a finished pad against which the work is held. The locating pins extend clear through the central portion of the jig body, and, consequently, will locate the component

* MACHINERY, October, 1908.

part of the work in exactly the same position as the piece of work being drilled on the front side of the jig. The same clamping straps are used, the screws being simply put in from the opposite side into the same tapped holes as are used when clamping on the front side of the jig. The four holes *D* are guide holes for drilling the screw holes in the work, these being drilled the body size of the bolt in one part, and the tap drill size in the component part. The lining bushing in the holes *D* serves as a drill bushing for drilling the body size holes. The loose bushing *E*, Fig. 73, is used when drilling the tap holes in the component part, the inside diameter of this bushing being the tap drill size, and the outside diameter a good fit in the lining bushing. The two holes *F*, Fig. 74, are provided with drill bushings and serve as guides when drilling the dowel pin holes, which are drilled below size, leaving about 0.010 inch, and are reamed out

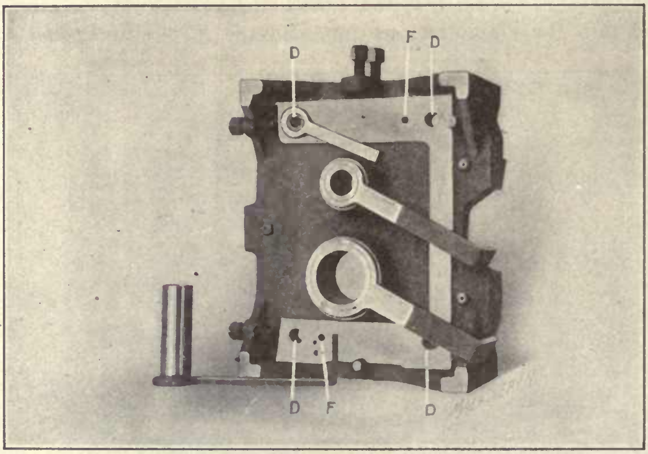


Fig. 74. Rear View of Drill Jig shown in Fig. 73

after the two component parts of the work are put together. The two holes shown in the middle of the jig in Fig. 73, and which are provided with lining bushings, and also with loose bushings, as shown inserted in Fig. 74, may be used for drilling and reaming the bearing holes for the shafts passing through the work. In this particular case, however, they are only used for rough-drilling the holes, to allow the boring-bars to pass through when finishing the work by boring in a special boring jig, after the two parts of the work have been screwed together.

The large bushings shown beside the jig in Fig. 73 are the loose bushings shown in place in Fig. 74. It will be noted that the bushings are provided with dogs for easy removal, as explained in Chapter II, and illustrated in Fig. 11. As the central portion of the jig body is rather thin, it will be noticed in Fig. 74 that the bosses for the central holes project outside of the jig body in order to give a long enough bearing to the bushings. This, of course, can be done

only when such a projection does not interfere with the work. The bosses, in this particular case, also serve another purpose. They make the jig "fool-proof," because the pieces drilled on the side of the jig shown in Fig. 73 cannot be put on the side shown in Fig. 74, the bosses preventing the piece from being placed in position in the jig.

Attention should be called to the simplicity of the design of this jig. It simply consists of a cast-iron plate, with finished seats, and feet projecting far enough to reach below the work when drilling, three dowel pins, set-screws for bringing the work up against the dowel pins, three clamps, and the necessary bushings. The heads of all the set-screws and bolts should, if possible, be made the same size, so that the same wrench may be used for tightening and unscrewing all of them. It can also be plainly seen from the half-tones that there

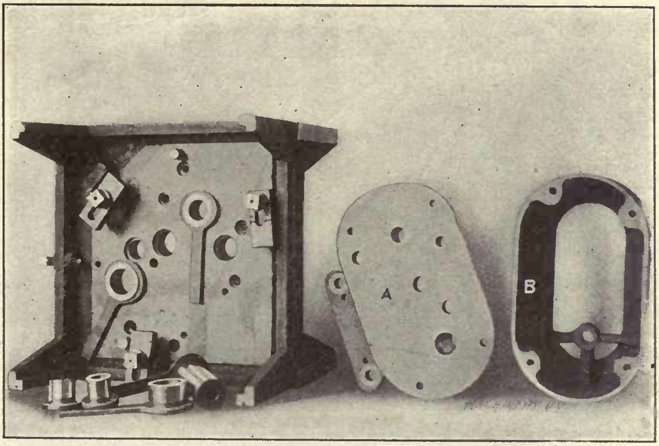


Fig. 75. Drill Jig Used for Drilling Work shown to the Right

are no unnecessarily finished surfaces on the jig, a matter which is highly important in economical production of tools.

Another example of an open drill jig, similar in design to the one just described, is shown in Fig. 75. The work to be drilled in this jig is shown at *A* and *B* at the right-hand side of the jig. In this case, the work is located from the half-circular ends. The pieces *A* and *B* are component parts, and when finished are screwed together. The piece *A* is located against three dowel pins, and pushed against them by set-screw *C*, and held in position by three clamping straps, as shown in Fig. 76. In this case, the straps are provided with oblong slots as indicated, and when the clamp screws are loosened, the clamps are simply pulled backward, permitting the insertion and removal of the work without interference. It would improve this clamping arrangement to place a stiff helical spring around the screws under each strap, so that the straps would be prevented from falling down to the bottom of the jig when the work is removed. At the same time this

would prevent the straps from swiveling around the screws when not clamped.

In Fig. 77, the part *B* in Fig. 75 is shown clamped in position for drilling, the opposite side of the jig being used for this purpose. In

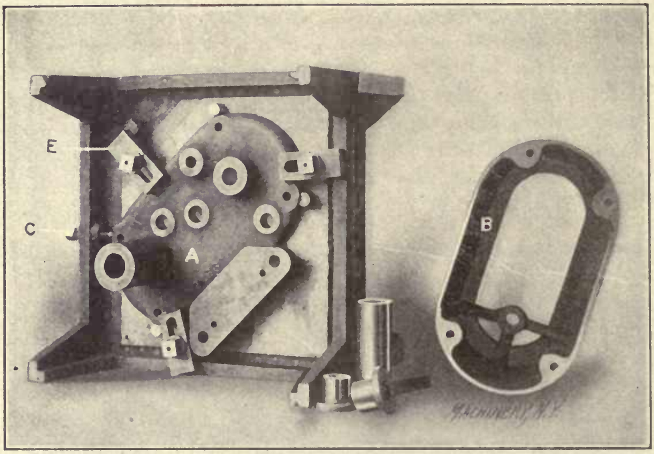


Fig. 76. Drill Jig shown in Fig. 75 with Work in Place

jig design of this kind it is necessary to provide some means so that the parts *A* and *B* will be placed each on the correct side of the jig, or, as said before, the jig should be made "fool-proof." In the present

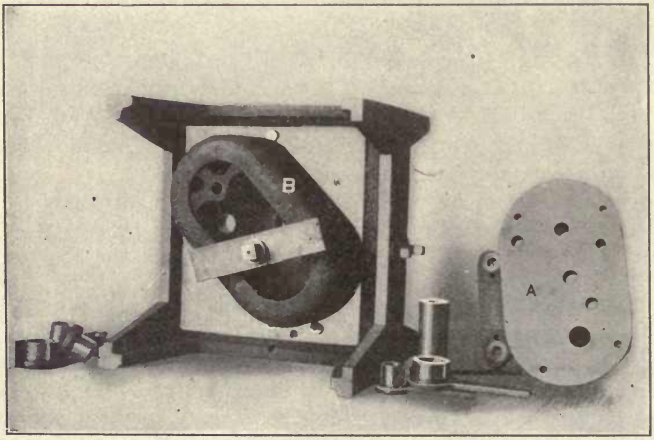


Fig. 77. Rear View of Drill Jig shown in Fig. 75, with Cover to be Drilled in Place

case, the parts cannot be exchanged and placed on the wrong side, because the cover or guard *B* cannot be held by the three straps in Fig. 76, because the screws for the straps are not long enough. On the other hand, the piece *A* could not be placed on the side shown in

Fig. 77, because the long bolt and strap used for clamping on this side would interfere with the work.

It may appear to be a fault in design that three straps are used to fasten the piece *A* in place, and only one is employed for holding piece *B*. This difference in clamping arrangement, however, is due to the different number and the different sizes of holes to be drilled in the different pieces. The holes in the piece *A* are larger and the number of holes is greater, and a heavier clamping arrangement is, therefore, required, inasmuch as the thrust on the former is correspondingly greater, the multiple spindle drill being used for drilling the holes. If each hole were drilled and reamed individually, the design of the jig could have been comparatively lighter.

In the design shown, the locating of each piece individually in any but the right way is also taken care of. The piece *A*, which is shown

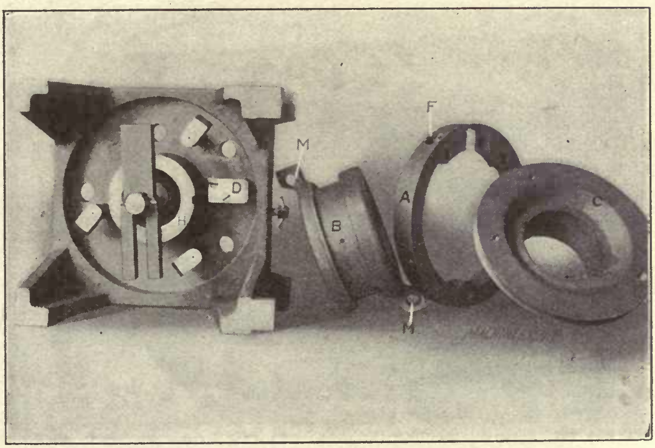


Fig. 78. Drill Jig for Parts of Friction Clutches shown at the Right

in place in the jig Fig. 76, could not be swung around into another position, because the strap and screw at *E* would interfere. For the same reason, the cover or guard *B* could not be located except in the right way. As shown in Fig. 77, the strap and screw would have to be detached from the jig in order to get the cover in place, if it were turned around. The locating pins for the work pass clear through the body of the jig, and are used for locating both pieces. The pieces are located diagonally in the jig, because, by doing so, it is possible to make the outside dimensions of the jig smaller. In this particular case the parts are located on the machine to which they belong, in a diagonal direction, so that the additional advantage is gained of being able to use the same dimensions for locating the jig holes as are used on the drawing for the machine details themselves. This tends to eliminate mistakes in making the jigs as well.

Sometimes, when more or less complicated mechanisms are composed of several parts fitted together and working in relation to each

other, as, for instance, friction clutches, one jig may be made to serve for drilling all the individual parts, by the addition of a few extra parts applied to the jig when different details of the work are being drilled. In Figs. 78, 79, and 80, such a case is illustrated. The pieces *A*, *B*, and *C*, in Fig. 78, are component parts of a friction clutch, and the jig in which these parts are being drilled, is shown in the same figure, to the left. Suppose now that we wish to drill the friction expansion ring *A*. The jig is bored out to fit the ring before it is split, and when it is only rough-turned, leaving a certain number of thousandths of an inch for finishing. The piece is located, as shown in Fig. 79, against the steel block *D* entering into the groove in the ring, and is then held by three hook-bolts, which simply are swung around when the ring is inserted or removed. The hook-bolts are tightened by nuts on the back side of the jig. Three holes marked

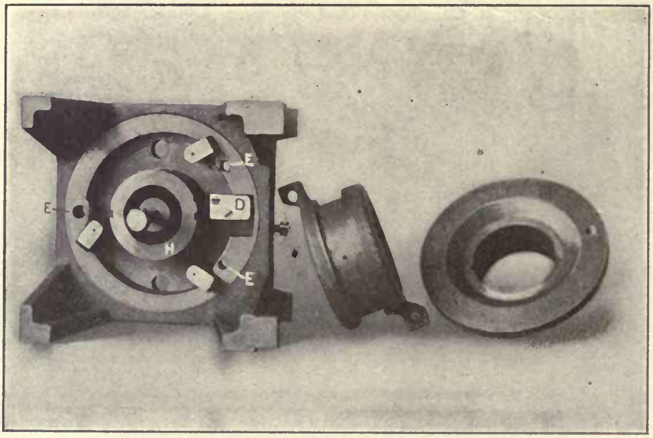


Fig. 79. Drill Jig shown in Fig. 78, with One of the Pieces in Place

E in Fig. 79, are drilled simultaneously in the multiple spindle drill, and the fourth hole *F* (see Fig. 78), is drilled by turning the jig on the side. The steel block *D*, Fig. 79, is hardened, and has a hole to guide the drill when passing through into the other side of the slot in the ring. The block is held in place by two screws and two dowel pins.

When drilling the holes in the lugs in the friction sleeve *B*, Fig. 78, the block *D* and the hook-bolts are removed. It may be mentioned here, although it is a small matter, that these parts should be tied together when removed, and there should be a specified place where all the parts belonging to a particular jig should be kept when not in use. The friction sleeve *B* fits over the collar *G*, Fig. 80. This collar is an extra piece, belonging to the jig, and used only when drilling the friction sleeve; it should be marked with instructions for what purpose it is used. The collar *G* fits over the projecting finished part *H* in the center of the jig, and is located in its right position by the keyways shown. The keyway in the friction sleeve *B*, which

must be cut and placed in the right relation to the projecting lugs before the piece can be drilled, locates the sleeve on the collar *G*, which is provided with a corresponding keyway. A flange on the collar *G*, as shown more plainly at *L* in Fig. 80, locates the friction sleeve at the right distance from the bottom of the jig, so that the holes will have a proper location sideways. Two collars, *G* and *L*, are used for the same piece *B*, this being necessary because the holes *M* and *M* in the projecting lugs shown in Fig. 78 are not placed in the same relation to the sides of the friction sleeve. The collars are marked to avoid mistakes, and corresponding marks on the jig provided so as to assure proper location. The friction sleeve is clamped in place by a strap which in this case does not form an integral part of the jig. This arrangement, however, is cheaper than it would have been to carry up two small projections on two sides of the jig, and

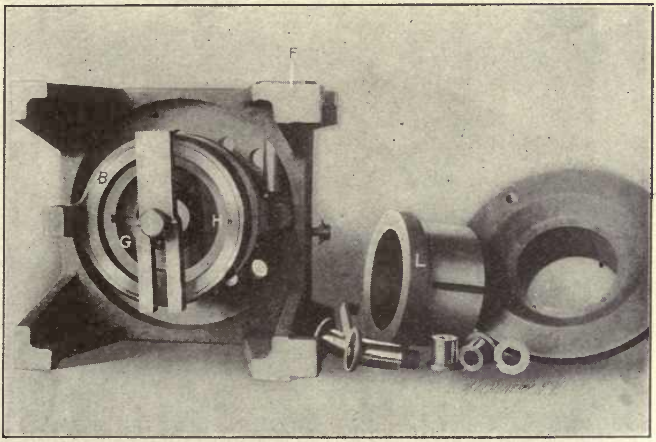


Fig. 80. Drill Jig shown in Fig. 78 used for Drilling Friction Sleeve

employ a swinging leaf and an eye-bolt, or some arrangement of this kind. Besides, the strap is rather large, and could not easily get lost. The jig necessarily has a number of loose parts, on account of being designed to accommodate different details of the friction clutch.

The friction disks *C*, in Fig. 78, when drilled, fit directly over the projecting finished part *H* of the jig, and are located on this projection by a square key. The work is brought up against the bottom of the jig and held in this position by the strap used in Fig. 80 for holding the friction sleeve. The bushings of different sizes shown in Fig. 80, are used for drilling the different sized holes in the different parts.

In all the various types of drill jigs described above, the thrust of the cutting tools is taken by the clamping arrangement. In many cases, however, no actual clamping arrangements are used, but the work itself takes the thrust of the cutting tools, and one depends entirely upon the locating means to hold the piece or jig in the right

position when performing the drilling operation. It may be well to add that large bushings ought to be marked with the size and kind of cutting tool for which they are intended; and the corresponding place in the jig body where they are to be used should be marked so that the right bushing can easily be placed in the right position.

A few more examples of open drill jig designs of various types may prove instructive. In Fig. 81 are shown two views of a jig for drilling two holes through the rim of a hand-wheel. To the left is shown the jig itself and to the right the jig with the hand-wheel mounted in place, ready for drilling. As shown, the hand-wheel is located on a stud through its bore, and clamped to the jig by passing a bolt through the stud, this bolt being provided with a split washer on the end. The split washer permits the easy removal of the hand-wheel when drilled, and the putting in place of another hand-wheel without

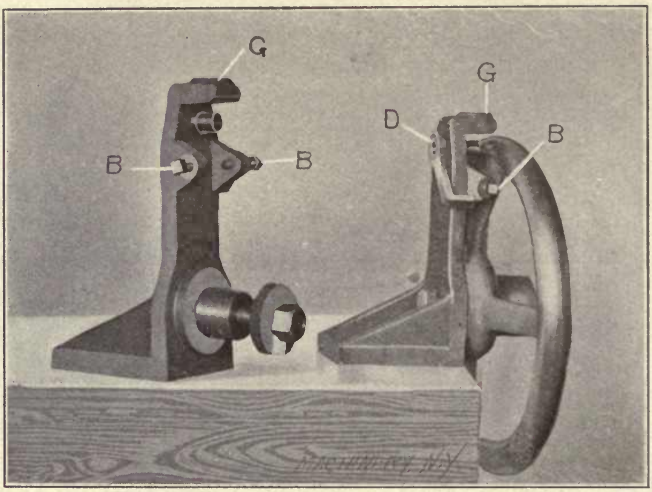


Fig. 81. Drill Jig for Holes in Rim of Hand-wheel

loss of time. The hand-wheel is located by two set-screws *B* passing through two lugs projecting on each side of a spoke in the hand-wheel, the set-screws *B* holding the hand-wheel in position while being drilled by clamping against the sides of the spoke. The jig is fastened on the edge of the drill press table, in a manner similar to that indicated in the half-tone, so that the table does not interfere with the wheel. The vertical hole, with the drill guided by bushing *G*, is now drilled in all the hand-wheels, this hole being drilled into a lug in the spoke held by the two set-screws *B*. When this hole is drilled, the jig is moved over to a horizontal drilling machine, and the hole *D* is drilled in all the hand-wheels, the jig being clamped to the table of this machine in a similar manner as on the drill press.

In Fig. 82, at *A*, an open drill jig of a type similar to those shown in Figs. 73 and 75, is shown. This jig, however, is provided with a V-block locating arrangement. An objectionable feature of this jig

is that the one clamping strap is placed in the center of the piece to be drilled. Should this piece be slender, it may cause it to bend, as there is no bearing surface under the work at the place where the clamp is located, for taking the thrust of the clamping pressure.

At *B* and *C* in the same engraving are shown the front and back views of a drill jig, where the front side *B* is used for drilling a small piece located and held in the jig as usual; and the back side *C*, which

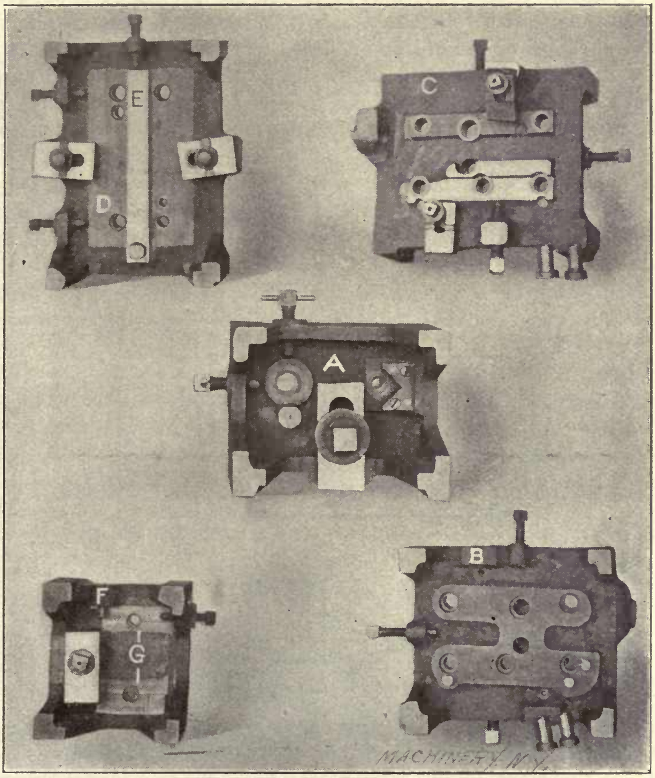


Fig. 82. Miscellaneous Examples of Open Drill Jigs

is not provided with feet, is located and applied directly on the work itself in the place where the loose piece is to be fastened, the work in this case being so large that it supports the jig, instead of the jig supporting the work.

At *D* in the same engraving is shown a jig for locating work by means of a tongue *E*. This tongue fits into a corresponding slot in the work. This means for locating the work was referred to more completely in connection with locating devices. Finally, at *F*, is shown a jig where the work is located by a slot *G* in the jig body, into which a corresponding tongue in the work fits.

CHAPTER VII

DESIGN OF CLOSED OR BOX JIGS*

In Chapters V and VI, the subject of the design of open drill jigs has been dealt with. In the present chapter it is proposed to outline the development of the design of closed or box jigs.

We will assume that the holes in a piece of work, as shown in Fig. 83, are to be drilled. Holes *A* are drilled straight through the work, while holes *B* and *C* are so-called "blind holes," drilled into the work from the opposite sides. As these holes must not be drilled through, it is evident that the work must be drilled from two sides, and the guiding bushings for the two blind holes must be put in opposite sides of the jig. The simplest form of jig for this work is shown in Fig. 84. The piece of work *D* is located between the two plates *E*, which form the jig, and which, if the jig be small, are made of machine steel and case-hardened. If the jig is large these plates

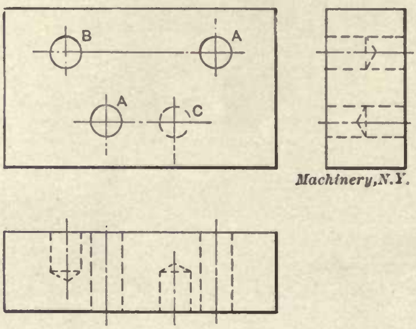


Fig. 83. Work to be Drilled

are made of cast iron. The work *D* is simply located by the outlines of the plates, which are made to the same dimensions, as regards width, as the work itself. The plates are held in position in relation to each other by the guiding dowel pins *F*. These pins are driven into the lower plate and have a sliding fit in the upper one. In some cases, blocks or lugs on one plate would be used to fit into a slot in the other plate instead of pins. These minor changes, of course, depend upon the nature of the work, the principle involved being that some means must be provided to prevent the two plates from shifting in relation to each other while drilling. The whole device is finally held together by clamps of suitable form. The holes *A* may be drilled from either side of the jig, as they pass clear through the work, and the guides for the drills for these holes may, therefore, be placed in either plate. Opposite the bushings in either plate a hole

* Machinery, November, 1908.

is drilled in the other plate for clearance for the drill when passing through, and for the escape of the chips.

The two plates should be marked with necessary general information regarding the tools to be used, the position of the plates, etc., to prevent mistakes by the operator. It is also an advantage, not to

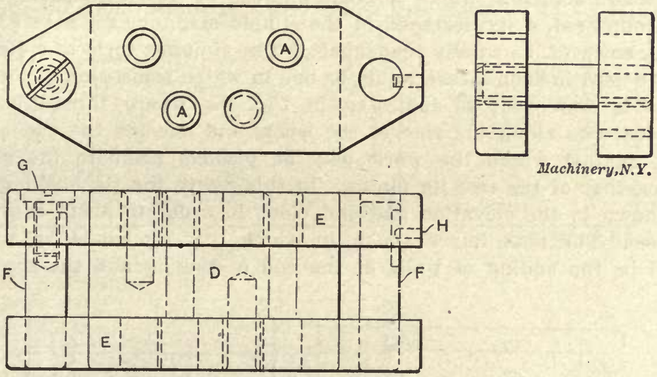


Fig. 84. Simplest Form of Closed Jig for Drilling Work in Fig. 83

say a necessity, to use some kind of connection between the plates in order to avoid such mistakes, as for instance, the placing of the upper plate in a reversed position, the wrong pins entering into the dowel pin holes. This, of course, would locate the holes in a faulty position. Besides, if the upper plate be entirely loose from the lower, it may

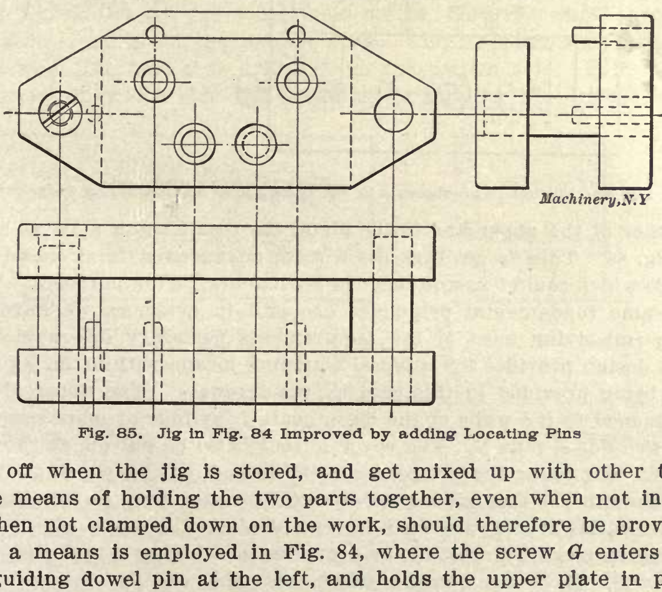


Fig. 85. Jig in Fig. 84 Improved by adding Locating Pins

drop off when the jig is stored, and get mixed up with other tools. Some means of holding the two parts together, even when not in use, or when not clamped down on the work, should therefore be provided. Such a means is employed in Fig. 84, where the screw *G* enters into the guiding dowel pin at the left, and holds the upper plate in place. A pin *H*, fitting into an elongated slot in the dowel pin as shown at

the left, could also be used instead of the screw. The design shown presents the very simplest form of box jig, consisting, as it does, of only two plates for holding the necessary guiding arrangements, and two pins or other means for locating the plates in relation to each other.

In manufacturing, where a great number of duplicate parts would be encountered, a jig designed in the simple manner shown in Fig. 84 would, however, be wholly inadequate. The simplest form of a jig that may be used in such a case would be one in which some kind of locating means is employed, as indicated in Fig. 85, where three pins are provided, two along the side of the work, and one for the end of the work, against which the work may be pushed, prior to the clamping together of the two jig plates. In this figure the jig bushings are not shown in the elevation and end view, in order to avoid confusion of lines. The next improvement to which this jig would be subject would be the adding of walls at the end of the jig and the screwing

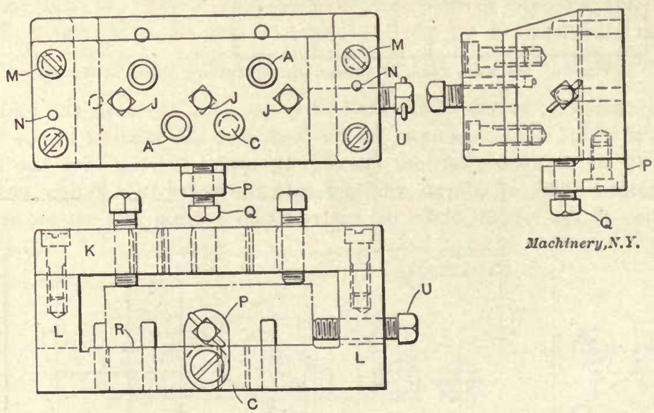


Fig. 86. Further Improvements in Jig, suiting it to Manufacturing Purposes

together of the upper and lower plate, the result being a jig as shown in Fig. 86. This design presents a more advanced style of closed jig—a type which could be recommended for manufacturing purposes. While the same fundamental principles are still in evidence, we have here a jig embodying most of the requirements necessary for rapid work. This design provides for integral clamping means within the jig itself, this being provided in this case by the screws *J*. The upper plate *K* is fastened to the walls of the lower plate *L* by four or more screws *M*, and two dowel pins *N*. The cover *K* could also be put on, as shown in Fig. 87, by making the two parts a good fit at *O*, one piece being tongued into the other. This gives greater rigidity to the jig. In this jig, also, solid locating lugs *F* are used instead of pins.

Referring again to Fig. 86, by providing a swinging arm *P* with a set-screw *Q*, the work can be taken out and can be inserted from the side of the jig, which will save making any provisions for

taking off or putting on the top cover for every piece being drilled. If there is enough clearance between the top cover and the piece being drilled, the screw *Q* could, of course, be mounted in a solid lug, but it would not be advantageous to have so large a space between the top plate and the work, as the drill would have to extend unguided for some distance before it would reach the work. The set-screws *Q*

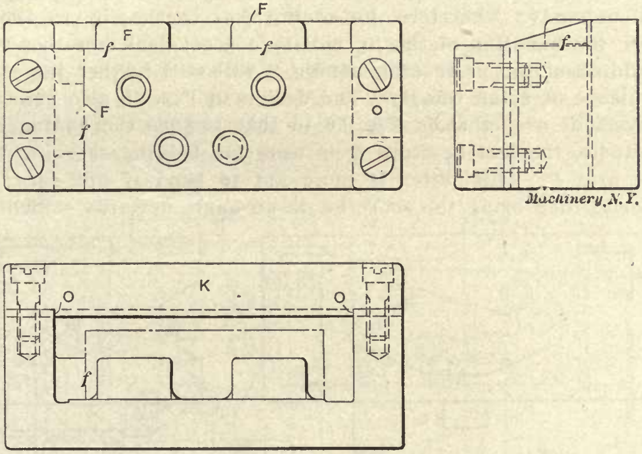


Fig. 87. Alternative Design of Jig shown in Fig. 86

and *U* hold the work against the locating points, and the set-screws *J* on the top of the jig, previously referred to, hold the work down on the finished pad *R* on the bottom plate. These screws also take the thrust when the hole *C* is drilled from the bottom side. It is rather immaterial on which side the bushings for guiding the drills for the

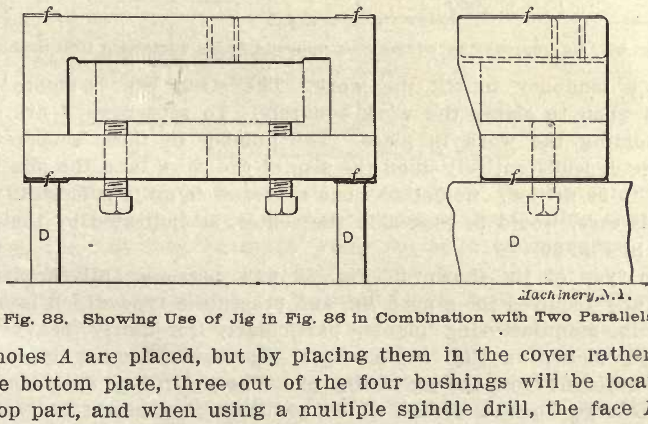


Fig. 88. Showing Use of Jig in Fig. 86 in Combination with Two Parallels

two holes *A* are placed, but by placing them in the cover rather than in the bottom plate, three out of the four bushings will be located in the top part, and when using a multiple spindle drill, the face *R* will take the greater thrust, which is better than to place the thrust on the binding screws *J*. In the designs in Figs. 86 and 87 the whole top and bottom face of the jig must be finished, or a strip marked *f* in

Fig. 88, at both ends of the top and bottom surfaces, must be provided, so that it can be finished, and the jig placed on parallels *D* as illustrated.

While the jig itself, developed so far, possesses most of the necessary points for rapid production and accurate work, the use of parallels, as indicated in Fig. 88, for supporting the jig when turned over so that the screw heads of the clamping screws point downward, is rather unhandy. Therefore, by adding feet to the jig, as shown in Fig. 89, the handling of the jig will be a great deal more convenient. The adding of the protruding handle *S* will still further increase the convenience of using the jig. The design in Fig. 89 also presents an improvement over that in Fig. 86 in that besides the adding of feet and handle, the leaf or strap *E* is used for holding screw *Q* instead of the arm *P*. This latter is more apt to bend if not very heavy, and would then bring the set-screw in an angle upwards, which would

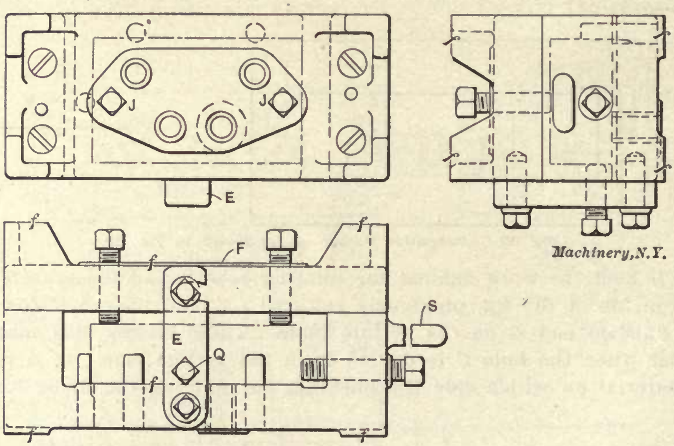


Fig. 89. Jig Improved by adding Feet opposite Faces containing Drill Bushings

have a tendency to tilt the work. The strap can be more safely relied upon to clamp the work squarely. To set-screws *J* are shown for holding the work in place. The number of these set-screws, of course, depends entirely upon the size of the work, and the size of the holes to be drilled. Sometimes one set-screw is quite sufficient, which, in this case, would be placed in the center, as indicated by the dotted lines in Fig. 86.

The type of jig shown in Fig. 89 now possesses all the features generally required for a good jig, and presents a type which is largely used in manufacturing plants, particularly for fairly heavy work. The jig shown in Fig. 90, however, represents another type, somewhat different from the jig in Fig. 89. The jig in Fig. 89 is composed of two large separate pieces, which, for large jigs, means two separate castings, involving some extra expense in the pattern-shop and foundry. The reason for making the jig in two parts, instead of casting it in one, is because it makes it more convenient when machining the

jig. The locating points, however, are somewhat hidden from view when the piece is inserted. The jig shown in Fig. 90 consists of only one casting *L*, provided with feet, and resembles an open drill jig. The work is located in a manner similar to that already described, and the leaf *D*, wide enough to take in all the bushings except the one for the hole that must be drilled from the opposite side, is fitted across the jig and given a good bearing between the lugs in the jig wall. It swings around the pin *E*, and is held down by the eye-bolt *F* with a nut and washer. Sometimes a wing-nut is handier than a hexagon nut. Care should be taken that the feet reach below the top of the nut and screw. The set-screw *G* holds the work down, and takes the thrust when the hole from the bottom side is drilled. The three holes *AA* and *B* are drilled from the top so that the thrust of

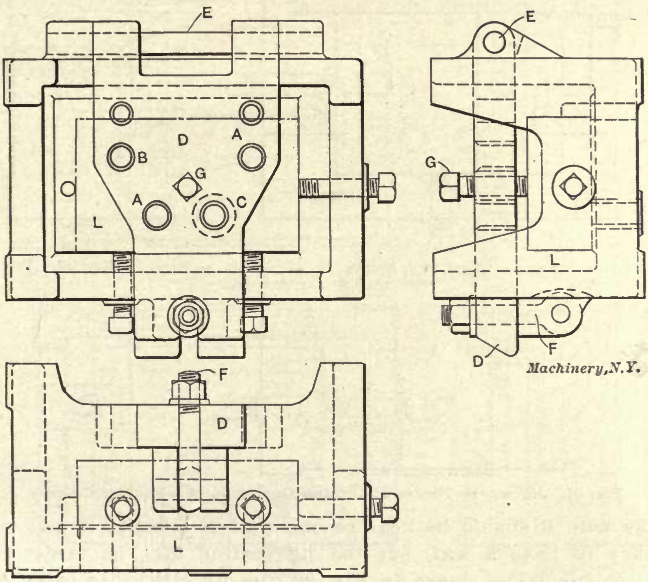


Fig. 90. Alternative Design of Jig in Fig. 89

the drilling these three holes will be taken by the bottom of the jig body *L*. If one set-screw *G* is not sufficient for holding the work in place, the leaf may be made wider so as to accommodate more binding screws.

It should be mentioned here, however, that it is an objectionable feature to place the clamping screws in the bushing plate. If the leaf has not a perfect fit in its seats and on the swiveling pin, the screws will tilt the leaf one way or another, and thus cause the bushings to stand at an angle with the work, producing faulty results. In order to avoid this objectionable feature, a further improvement on the jig, indicated in Fig. 91, is proposed. In the jig body, the locating points and the set-screws which hold the work against the locat-

ing pins are placed so that they will not interfere with two straps *G*, which are provided with elongated slots, and hold the work securely in place, also sustaining the thrust from the cutting tools. These straps should be heavily designed, in order to be able to take the thrust of the multiple spindle drill, because in this case all the bushings except the one for hole *B* are placed in the bottom of the jig body. The leaf is made narrower and is not as heavy as the one shown in Fig. 90, because it does not, in this case, take any thrust when drilling, and simply serves the purpose of holding the bushing for hole *B*. The leaves and loose bushing plates for jigs of this kind are generally made of machine steel, but for larger sized jigs they may be made of cast iron. The leaf in Fig. 91 is simply held down by the thumb-screw *H* of a type as shown in Fig. 48 in Chapter IV.

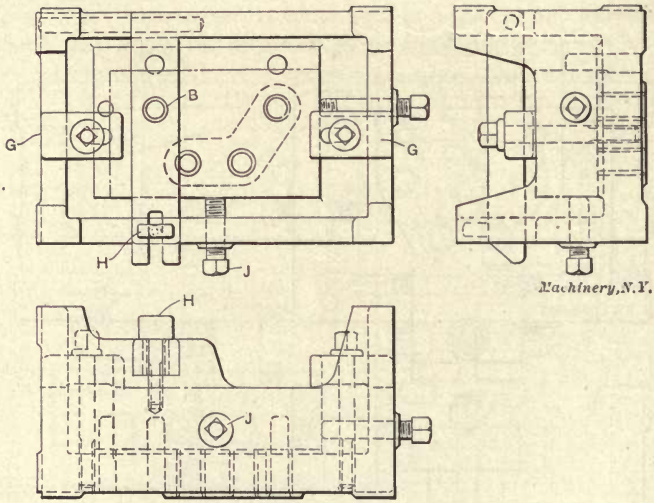


Fig. 91. Jig where Thrust of Drilling Operation is taken by Clamps

If the hole *B* should be near to one wall of the jig, it may not be necessary to have a leaf, but the jig casting may be made with a projecting lug *D*, as shown in Fig. 92, the jig otherwise being of the same type as the one illustrated in Fig. 91. The projecting part *D*, Fig. 92, is strengthened, when necessary, by a rib *E*, as indicated. Care must be taken that there is sufficient clearance for the piece to be inserted and removed. Once in a while it happens, even with fairly good jig designers, that an otherwise well-designed jig with good locating, clamping, and guiding arrangements, is rendered useless for the simple reason that there is not enough clearance to allow the insertion of the work. The jig shown in Fig. 92 resembles, in reality, an open jig more than a closed jig.

Fig. 93 shows the same jig as before, but with the additional feature of permitting a hole in the work to be drilled from the end and side as indicated, the bushings *E* and *F* being added for this purpose. It will be noticed that the bushings in this case extend through the

jig wall for some distance, in order to guide the drill closely to the work. Bosses may also be cast on the jig body, as indicated by the dotted lines, to give a longer bearing for the bushings.

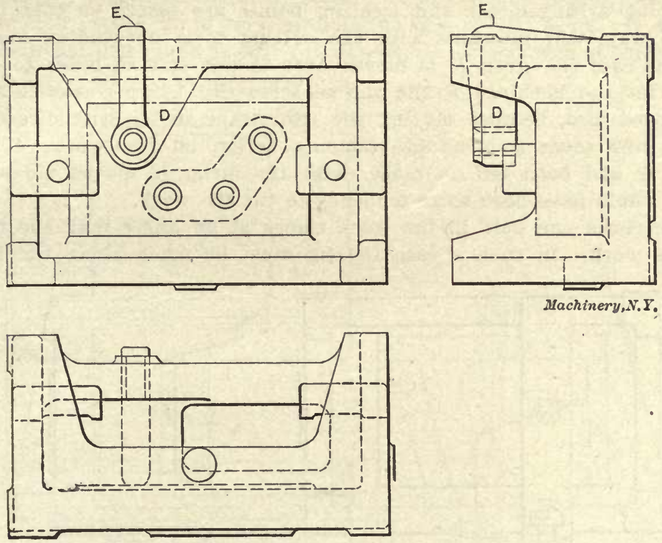


Fig. 92. Modification of Jig in Fig. 91, which practically brings it into the Class of Open Drill Jigs

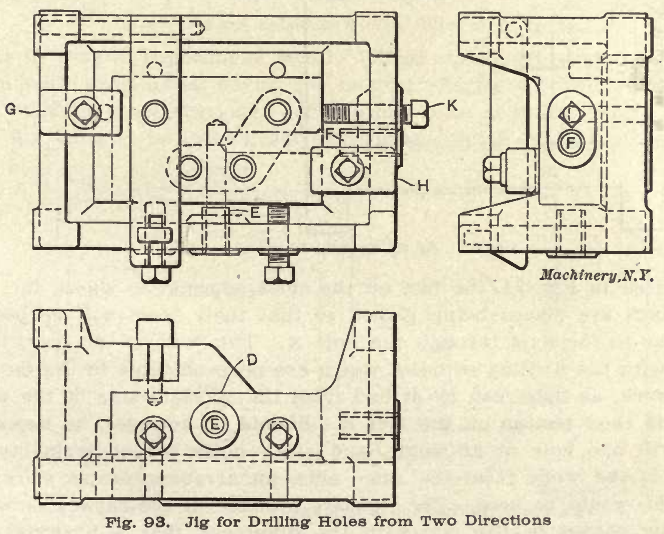


Fig. 93. Jig for Drilling Holes from Two Directions

Feet or lugs are cast and finished on the sides of the jig opposite the bushings, so that the jig can be placed conveniently on the drill press table for drilling in any direction. It will be noticed that when drilling the holes from the bushings *E* and *F*, the thrust is

taken by the stationary locating pins. It is objectionable to use set-screws to take the thrust, although in some cases it is necessary to do so. When designing a jig of this type, care must be taken that strapping arrangements and locating points are placed so that they, in no way, will interfere with the cutting tools or guiding means. In this case the strap *H* is moved over to one side in order to give room for the bushings *F* and the set-screw *K*. Strap *G* should then be moved also, because moving the two straps in opposite directions still gives them a balanced clamping action on the work. If the strap *G* had been left in place, with the strap *H* moved sideways, there would have been some tendency to tilt the work.

Sometimes one hole in the work comes at an angle with the faces of the work. In such a case the jig must be made along the lines

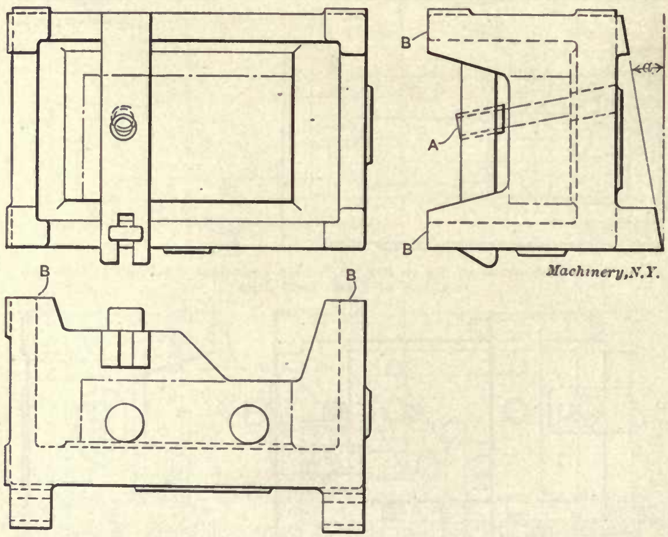


Fig. 94. Jig for Drilling Holes at an Angle

indicated in Fig. 94, the feet on the sides opposite to where the drill bushings are placed being planed so that their faces will be perpendicular to the axis through the hole *A*. This will, in no way, interfere with the drilling of holes which are perpendicular to the faces of the work, as these can be drilled from the opposite side of the work, the jig then resting on the feet *B*. Should it, however, be necessary to drill one hole at an angle, and other holes perpendicular to the face of the work from the same side, an arrangement as shown in Fig. 95 would be used. The jig here is made in the same manner as the jig shown in Fig. 93, with the difference that a bushing *A* is placed at the required angle. It will be seen, however, that as the other holes drilled from the same side must be drilled perpendicularly to the faces of the work, it would not be of advantage to plane the feet so that the hole *A* could be drilled in the manner previously

shown in Fig. 94. Therefore the feet are left to suit the perpendicular holes, and the separate base bracket *B*, Fig. 95, is used to hold the jig in the desired inclined position when the hole *A* is drilled.

Stand *B* in Fig. 95 is very suitable for this special work. It will be noticed that it is made up as light as possible, being cored at the center,

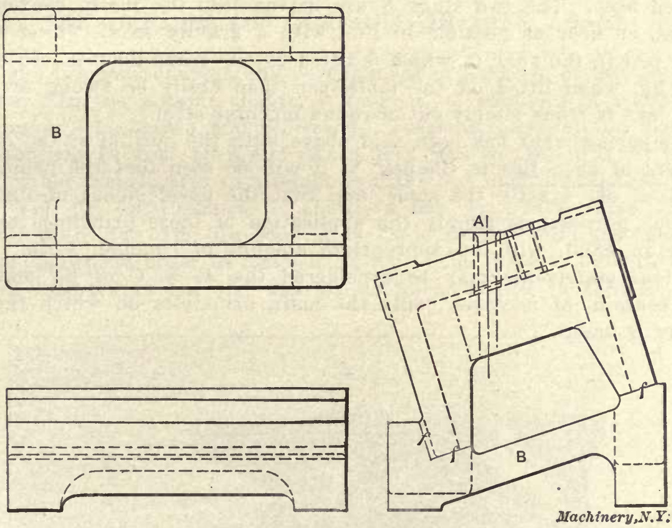


Fig. 95. Jig and Stand for Drilling Holes at an Angle

so as to remove superfluous metal. These stands are sometimes provided with a clamping device for holding the jig to the stand. Special stands are not only used for drilling holes at angles with the remaining holes to be drilled, but sometimes special stands are made to

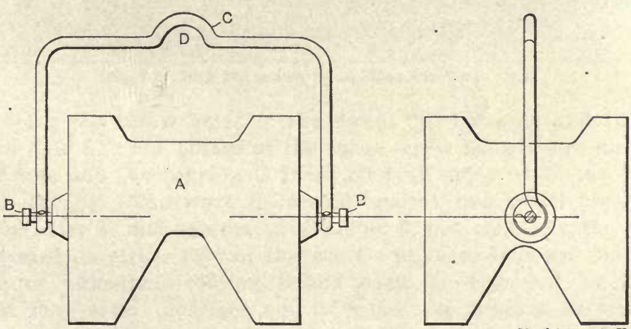


Fig. 96. Device for Turning over and Handling Heavy Jigs

suit the jig in cases where it would be inconvenient to provide the jig with feet, finished bosses or lugs, for resting directly on the drill press table.

When a jig of large dimensions is to be turned over, either for the insertion or removal of the work, or for drilling holes from opposite

sides, a helper will have to be called upon to assist the operator. The disadvantage of this is readily seen. In cases where the use of a crane or hoist can be obtained, it is very satisfactory to have a special device attached to the jig for turning it over. Fig. 96 shows such an arrangement. In this engraving, *A* represents the jig which is to be turned over. The two studs *B* are driven into the jig in convenient places, as near as possible in line with a gravity axis. These studs then rest in the yoke *C*, which is lifted by the crane hook placed at *D*. The jig, when lifted off the table, can then easily be swung around. The yoke is made simply out of round machine steel.

Comparing what has been said above with the outline of the development of open jigs in Chapter V, it will be seen that the principles involved are exactly the same, and that the development of jigs for various purposes is simply the application of these principles to the work in hand, with an appropriate amount of common sense. The previous statements may be considered the A, B, C of jig making, and contain, of necessity, only the main principles on which the jig design is based.

CHAPTER VIII

EXAMPLES OF CLOSED OR BOX JIGS*

In the previous chapter, the development of a closed or box jig was treated. In the present chapter a number of examples of closed jig designs will be shown and described. There is, however, no distinct division line between open and closed drill jigs, so that in many cases it is rather inconsistent to attempt to make any such distinction.

In Fig. 97, for instance, is shown a box jig which looks like a typical open jig. The jig body *A* is made in one solid piece, cored out as shown, in order to make it lighter. The piece to be drilled, *B*, shown inserted in the jig, has all its holes drilled in this jig, the

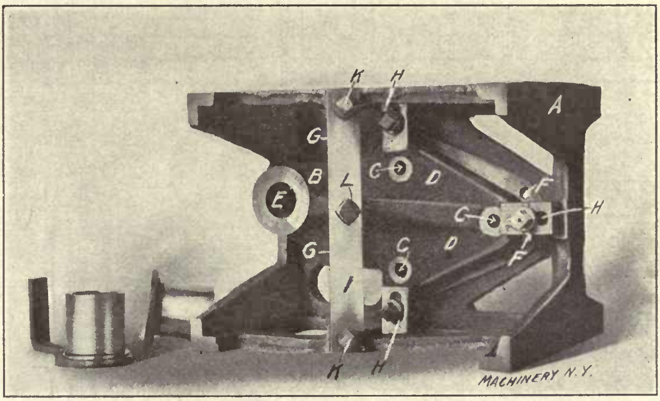


Fig. 97. Box Jig which Resembles the Open Type

holes being the screw holes *C*, the dowel pin holes *D*, and the large bearing hole *E*. The bosses of the three screw holes *C* are also faced on the top, and the bearing is faced on both sides while the work is held in the jig. The work is located against two dowel pins driven into the holes *F*, and against two lugs at *G*, not visible in the engraving, located on either side of the work. In these lugs are placed set-screws or adjustable sliding points such as described in Chapter III. It may seem incorrect not to locate the bracket in regard to the hole *E* for the bearing, so as to be sure to bring the hole concentric with the outside of the boss. This ordinarily is a good rule to follow, but in this particular case it is essential that the screw holes be placed in a certain relation to the outline of the bracket in order to permit this to match up with the pad on the machine on which the bracket is used. Brackets of this shape may be cast very

* MACHINERY, December, 1908.

uniformly, so that locating them in the manner described will not seriously interfere with drilling the hole *E* approximately in the center of its boss. The work is firmly held in the jig by the three straps *H*, care being taken in designing the jig that these straps are placed so they will not interfere with the facing tools.

The swinging strap *I*, which really is the only thing that makes this jig a closed jig, serves the sole purpose of taking the thrust of the heavy cutting tools when drilling the hole *E* and of steadying the work when facing off the two ends of the hub. The two collar-head screws *K* hold the strap to the jig body and the set-screw *L* bears against the work. This strap is easily swung out of the way

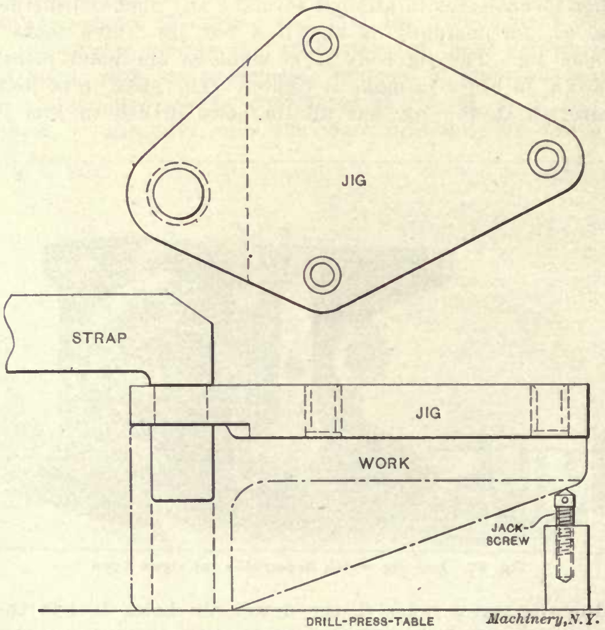


Fig. 98. Simple Form of Plate Jig for Drilling Bracket shown in Fig. 97, after Hole E has been bored in the Lathe

simply by loosening one of the collar-head screws, a slot being milled at one end of the strap to permit this. Stationary bushings are used for the screw hole and dowel holes, but for the bearing hole *E* three loose bushings and a lining bushing are employed. The hole *E* is first opened up by a small twist drill, which makes the work considerably easier for the so-called rose-bit drill. The latter drill leaves 1/16 inch of stock for the rose reamer to remove, which produces a very smooth, straight and concentric hole. The last operation is the facing of the holes. The holes just drilled are now used to guide the pilots of the facing tools, and as the operation is performed while the work is held in the jig, it is important that the locating or strapping arrangements should not be in the way.

In connection with the opening up of a hole with a smaller drill, it may be mentioned that it is not only for large holes that this method of procedure will save time, but the method is a time-saving one also for smaller holes, down to ¼ inch in diameter when drilled in steel.

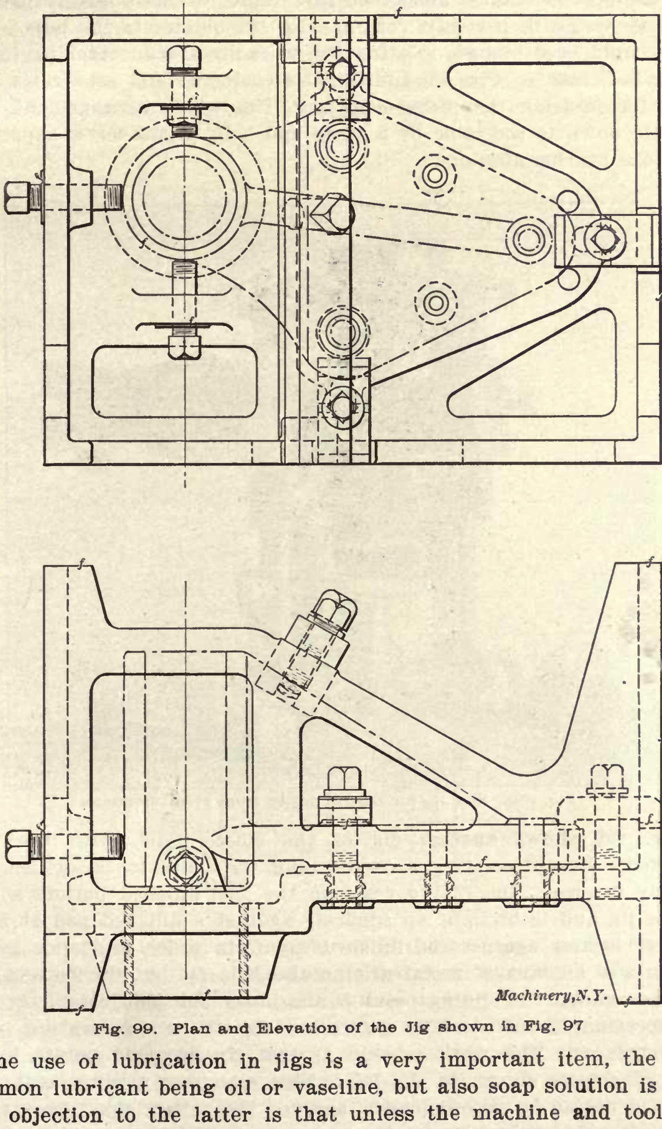


Fig. 99. Plan and Elevation of the Jig shown in Fig. 97

The use of lubrication in jigs is a very important item, the most common lubricant being oil or vaseline, but also soap solution is used. The objection to the latter is that unless the machine and tools are carefully cleaned, it is likely to cause rusting. Using a lubricant freely will save the guiding arrangements, such as the drill bushings, the pilots on counterbores, etc., to a great extent.

The jig in Fig. 97 is shown in Fig. 99, and a clear idea of the design of the jig will be had by studying this line engraving. The bracket *B*, in Fig. 97, could have been drilled in a different way than described, which will sometimes be an advantage. It could be held in a chuck, and the hole *E* reamed and faced in a lathe, which would insure that the hole would be perfectly central with the outside of the boss. Then a jig could be designed, locating the work by a stud entering in hole *E*, as indicated in Fig. 98, additional dowel pins and set-screws being used for locating the piece sidewise. The whole arrangement could be held down to the table by a strap and bolt, a jack-screw supporting it at the overhanging end.

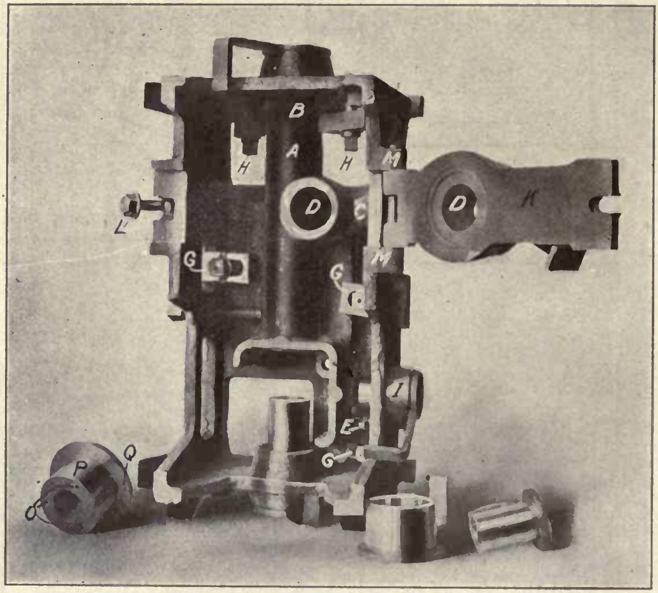


Fig. 100. Box Jig for Casing drilled from Five Directions

Fig. 100 shows another jig of the closed type, with the work inserted. The piece *A* is a casing, and the holes to be drilled vary greatly in size. The casing rests on the flat, finished bottom surface of the jig and is brought up squarely against a finished pad at *B*. It further locates against the finished lug *C* in order to insure getting the proper amount of metal around the hole *D*. At the bottom it is located against the sliding point *E*, the latter being adjustable because the location of the work is determined by the other locating points and surfaces. The work is held against the locating points by the long set-screws shown to the left. This clamping arrangement, however, is not to be recommended because this screw must be screwed back a considerable distance in order to permit insertion and removal of the work. An eye-bolt used in the manner previously described in Chapter IV of Part I would have given better service. The three

straps *G* hold the work against the bottom surface, and the two straps *H* hold it against the finished surface at *B*. There is not a long finished hole through the casting, as would be assumed from its appearance, but simply a short bearing at each end, the remaining part of the hole being cored out. For this reason the hole is drilled and reamed instead of being bored out, as the latter operation would be a slower one. Although the two short bearings are somewhat far apart, the guiding bushings come so close to these bearings that the alignment can be made very good. The screw holes and dowel pin holes at

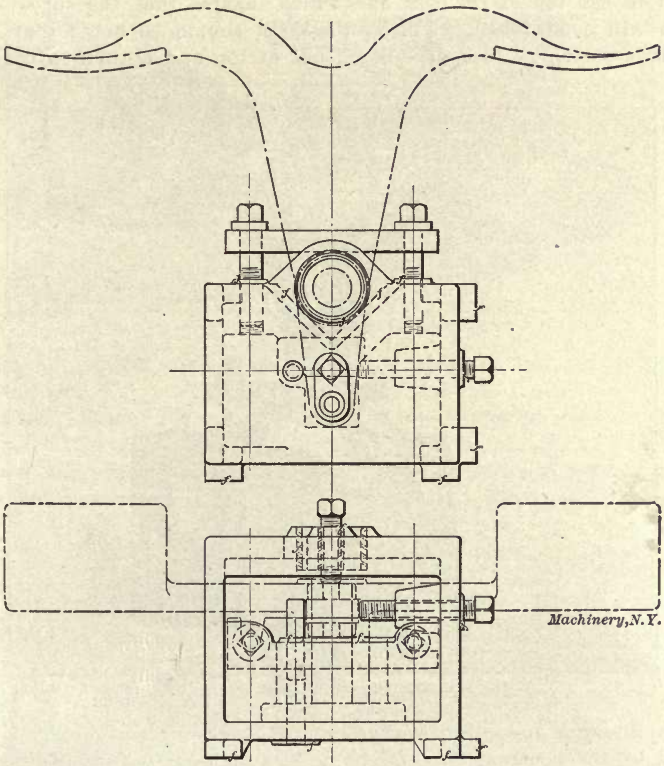


Fig. 101. Box Jig for Drilling Work shown in Dash-dotted Lines

the bottom of the casing are not shown in the half-tone, as the inserted casing is not yet drilled. The hole drilled from bushing *I* is a rather important hole, and the bushing requires a long bearing in order to guide the drills straight when drilling. When this jig was made, the projecting lug which was provided solid with the jig body, to give a bearing to the jig bushing, came so much out of the way in the rough casting for the jig that half of the lining bushing would have been exposed. It was therefore planed off and a bushing of the type shown in Fig. 9, Chapter II, inserted instead, in order to provide for a long bearing.

Leaf *K*, which carries the bushings for drilling the hole *D*, fits into a slot planed out in the jig body and is held down by the eye-bolt *L*. Two lugs *M* are provided on the main casting for holding the pin on which the leaf swivels, the construction being of the same type as illustrated in Fig. 50, Chapter IV. Around the hole *D* there are three small tap holes *O* which are drilled by the guiding afforded by the bushing *P*, which is made of cast iron and provided with small steel bushings placed inside as illustrated in Fig. 16, Chapter II. In the bushing *P* is another hole *Q* which fits over a pin located in the top of the leaf and which insures that the three screw holes will come in the right position. It should be noted that large portions of the jig body are cored out at top and bottom in order to

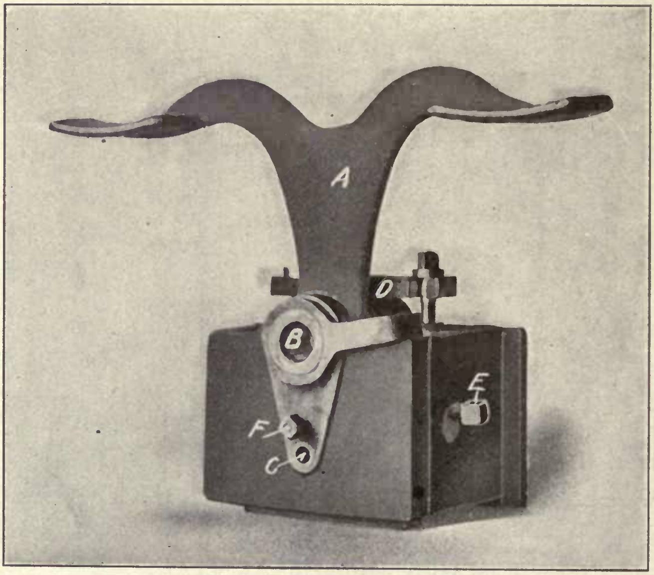


Fig. 102. Jig shown in Detail in Fig. 101

make it light and easy to handle. Of course some metal is also saved by the construction of jigs in this manner, but comparing the price of cast iron with the total price of a finished jig of this type, the saving in this respect is so insignificant that it is not worth while mentioning. The leaf *K* is also made of cast iron, being of particularly large size, and it is planed at the places where it has a bearing on the jig body.

Fig. 102 shows a closed jig about which there can be no doubt but that it should be classified as a box jig. The piece of work drilled, the foot trip *A*, has two holes *B* and *C* which are drilled in this jig. The cylindrical hub of the work is located against V-blocks and held in place by a swinging strap *D*. The work is further located against a stop pin placed opposite the set-screw *E*. The trip is located sidewise

by being brought against another stop by the set-screw *F*. One-quarter of a turn of the collar-head screw on the top of the jig releases the swinging strap which is then turned out of the way; this permits the trip to be removed and another to be inserted. Half a turn or less of the set-screws is enough to release and clamp the work against the stops mentioned. A line engraving of this jig is shown

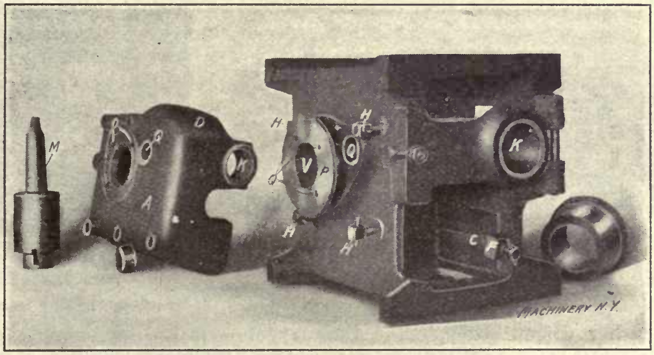


Fig. 103. Jig of Typical Design, and Work for which it is Used

in Fig. 101 which gives a better idea of some of the details of the construction.

In Figs. 103 and 104 are shown two views of another type of closed drill jig. The work *A*, to be drilled, is shown at the left in both illustrations, and consists of a special lathe apron with large bearing holes, screw holes, and dowel pin holes to be drilled. The apron is located

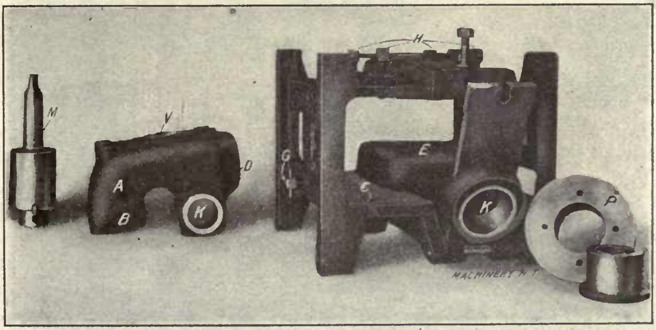
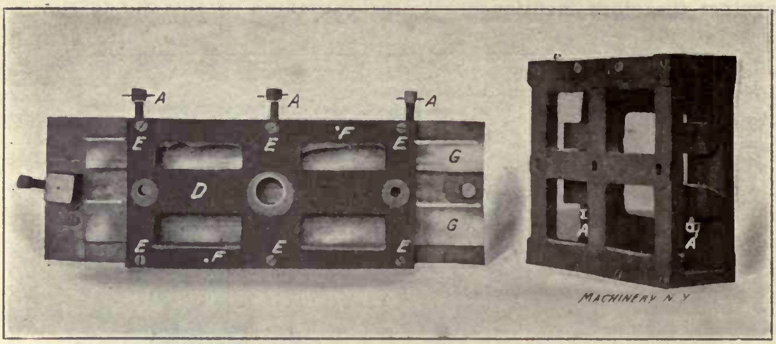


Fig. 104. Another View of the Jig in Fig. 103

in the jig body in the same manner as it is located on the lathe carriage, in this case by a tongue which may be seen at *B* in Fig. 104. This tongue fits into the slot *C* in the jig, care being taken in the construction of the jig that the slot is made deep enough to prevent the tongue from bearing in the bottom of the slot. A good solid bearing should be provided, however, for the finished surface on both sides of the tongue. The surface *D* should also have a solid bearing on the

surface *E* in the jig, the difference in height between the two bearing surfaces in the jig being exactly the same as between the two bearing surfaces on the lathe carriage where the lathe apron is to be fitted. The work is brought up against, and further located by, a dowel pin at the further end of the slot, by the set-screw in the block *F*, Fig. 103. As



Figs. 105 and 106. Jigs in which the Work is Located by Means of Beveled Surfaces

it is rather difficult to get the tongues on all the pieces exactly the correct width for a good fit in the slot, the latter is sometimes planed a little wider and the tongue is brought up against one side of the slot by set-screws. In the case in hand, a few thousandths inch clearance is provided in the slot and the set-screw *G* in Fig. 104 is used

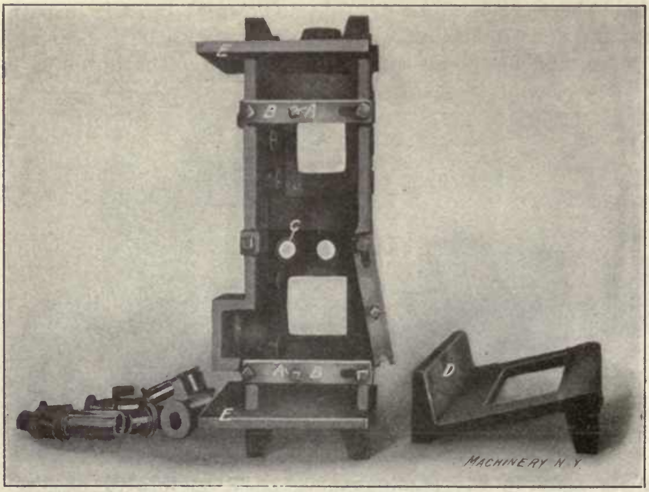


Fig. 107. Jig for Drilling Holes at other than 90-degree Angles

for bringing the work against the further edge which stands in correct relation to the holes to be drilled. The apron is held down against the bottom surface of the jig by four heavy set-screws *H*.

It will be noticed that the jig is open right through the sides in order to facilitate the finishing of the pads at the ends of the work,

and a swinging leaf like the one previously described, reaches across one side for holding the lining and loose bushings for the hole *K* which is drilled and rose-reamed in the usual way. The large hole *V*, Fig. 103, is bored out with a special boring tool *M*, as there are no standard drills obtainable for this large size of hole. This special boring tool is guided by a cast iron bushing which fits into the lining bushing; it is provided with two cutters, one for roughing and one for finishing. The small screw holes *O* around the large hole *V* are drilled from the bushing *P*. For drilling the rest of the holes, except the hole *Q*, stationary bushings are used. The screw holes ought to be drilled simultaneously in a multiple spindle drill. The jig is provided with feet and cored out in convenient places in order to make it as light as possible to handle. Lugs project wherever necessary to give ample

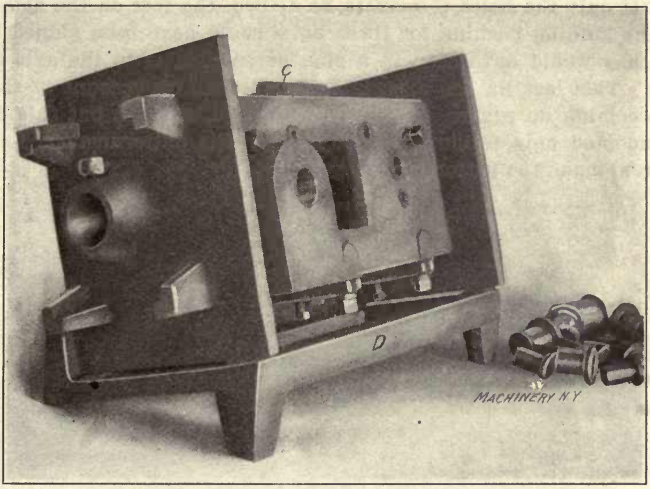


Fig. 108. Jig in Fig. 107 in Position for Drilling Holes at an Oblique Angle with Jig Base

bearings to the lining bushings and, in turn, to the loose guiding bushings.

Figs. 105 and 106 show two closed jigs made up of two main parts which are planed and assembled by screws and dowels as indicated, the reason for making the jigs in this way being the ease of planing the bottom section. The work drilled in these jigs, some special slides, is located by the dove-tail and held up against one dove-tail side by set-screws *A*, as shown in both illustrations. In Fig. 105 the work is located endwise against a dowel pin and is held up against this stop by a set-screw through the block shown to the left. This block must be taken out when the slide is inserted, this being the reason why a lug cast directly in place, through which the set-screw could pass, is not used. The top plate *D* is held down on the main body by six fillister-head screws *E*, and two dowel pins *F* prevent it from shifting. No clamping arrangements, except the set-screws *A*, are necessary. The

holes being drilled from the top, the main body of the jig takes the thrust. These jigs are also used in multiple spindle drills.

One objectionable feature of the jig in Fig. 106 is that set-screws *A* are difficult of access. There are, therefore, holes piercing the heads of the set-screws in two directions in order to allow a pin to be used when tightening the screws. A better idea, however, is to have the screw heads extend out through the wall, and if this is solid, to have cored or drilled holes through which the heads of the screws may pass.

In Fig. 107 is another closed drill jig in which the work is located against the finished seats and held down by the set-screws *A* in the straps *B*. All the holes, except the holes marked *C*, are drilled in the usual manner, the jig standing on its own feet, but when drilling the holes *C*, which come on an angle, the special stand *D* is employed which brings the holes in the right position for drilling, as illustrated in Fig. 108. If only the holes *C* were to be drilled, the feet on the side opposite the guiding bushing for these holes could have been planed off, so that they would have been in a plan perpendicular to the axis of the holes. This last jig has a peculiar appearance on account of the end walls coming up square, as shown in the illustrations, but this design was adopted only to simplify matters for the patternmaker, it being easier to make the pattern this way.

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JIGS AND FIXTURES—PART III

CHAPTER IX

PRINCIPLES OF BORING JIGS*

Boring jigs are as commonly used as drill jigs, in interchangeable manufacturing, and the requirements placed on drill jigs apply in most respects to boring jigs. Boring jigs are generally used for machining holes where accuracy of alignment and size are particularly essential, and also for holes of large sizes where drilling would be out of the question. Two or more holes in the same line are also, as a rule, finished with the aid of boring jigs.

The boring operation is performed by boring bars having inserted cutters of various kinds, and boring jigs are almost always used in connection with this kind of boring tool, although boring operations may be satisfactorily accomplished with three or four lipped drills and reamers. The reamers may be made solid, although most frequently shell reamers mounted on a bar and guided by bushings are used. The majority of holes produced in boring jigs, whether drilled or bored out, are required to be of such accuracy that they are reamed out in the last operation.

The boring bars are usually guided by two bushings, one on each side of the bored hole, and located as close as possible to each end of the hole being bored. The bar is rotated and simultaneously fed through the work, or the work with its jig is fed over the rotating bar. Boring jigs may be used either in regular boring lathes, in horizontal boring and drilling machines, or in radial drills.

The jig body is made either in one solid piece or composed of several members, the same as in drill jigs. The strain on boring jigs is usually heavy, which necessitates a very rigidly designed body with ribbed and braced walls and members, so as to allow the least possible spring. As boring jigs when in operation must be securely fastened to the machine table, means must also be provided in convenient and accessible places for clamping the jig without appreciably springing it.

The places in the jig where the bushings are located should be provided with plenty of metal so as to give the bushings a substantial bearing in the jig body. Smaller jigs should be provided with a tongue or lip on the surface which is clamped to the machine table; this permits the operator to quickly locate the jig in the right position. As an alternative, finished lugs locating against a parallel or square may be provided. It is frequently advantageous to have small sized boring jigs provided with feet so that they can be used on a

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* MACHINERY, January, 1909.

regular drill press table in cases where holes to be bored out are to be opened up with a drill piercing the solid metal. It is both easier and cheaper to do this rough drilling in a drill press.

The guide bushings, of the same type as the bushings for drill jigs, are made either of cast iron or steel and ground to fit the boring bar, which is also ground. The bars are made of machine steel and should be made as heavy as possible, in order to prevent them from bending or springing too much should there be a heavier cut on one side than on the other. The bushings should be made rather long to insure good bearing.

The most common type of boring jig for small and medium size work is shown in Fig. 109. In this engraving, *A* represents the work which is held down by straps or clamps. In many instances when the work is provided with bolt and screw holes before being bored, these holes are used for clamping the work to the jig. In some cases

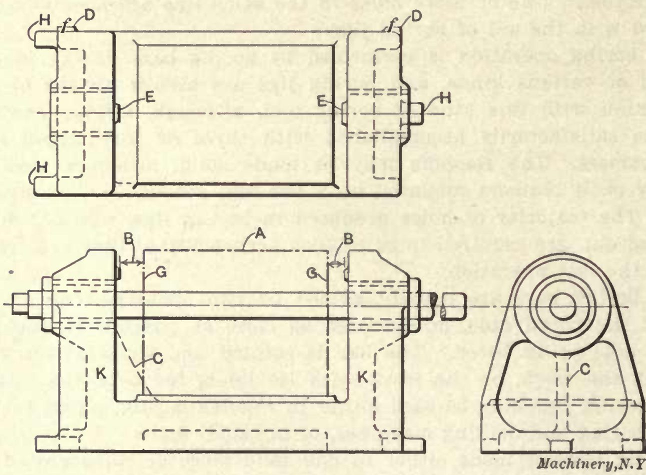


Fig. 109. General Outline of Simple Boring Jig

it is important that the work be attached to the jig in the same way as it is fastened to its component part in the machine for which it is made, and also that it be located in a similar way. If the work is located by V-slides when in use on the machine, it is preferable to locate it by V's in the jig. In other cases the locating arrangement for the work in the machine where it is to be used may be a tongue, a key, a dowel pin, a finished pad, etc. The same arrangement would then be used for locating it in the jig. In Fig. 109 enough clearance is left at *B*, at both ends, to allow for variations in the casting and to provide space for the chips; also, if the hole is to be reamed out, and the reamer be too large to go through the lining bushing, then the space left provides room for inserting the reamer and mounting it on the bar. In nearly all cases of boring, a facing operation of the bosses in the work has also to be carried out and provisions must be made in the jig to permit the insertion of facing tools.

A great deal of metal may be saved in designing heavy jigs by removing superfluous metal from those parts where it does not materially add to the strength of the jig. In Fig. 109, for instance, the jig can be cored out in the bottom and in the side standards as indicated without weakening the jig to any appreciable extent. The rib *C* may be added when necessary, and when it does not interfere with the work to be finished in the jig. It will be seen that extended bosses are carried out to provide long bearings for the bushings. The bosses may be made tapering, as shown, providing practically the same stiffness as a cylindrical boss containing considerable more metal. They must be given a rather liberal diameter, as they may not always be placed exactly correct on the pattern, and consequently be a little out of center in the casting. Finished bosses should be located at suitable places to facilitate the laying out and the making of the jig,

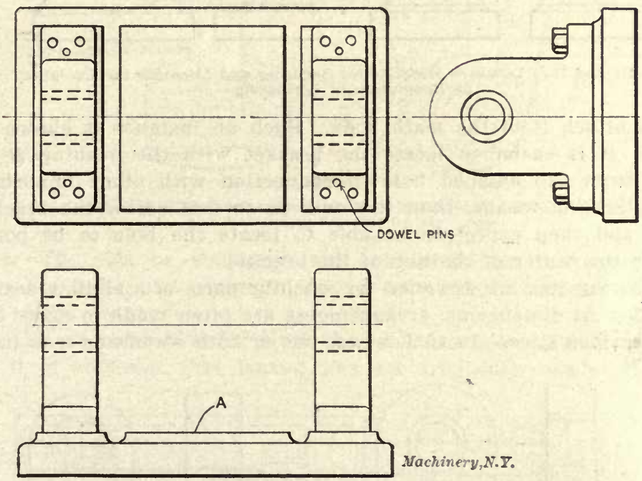


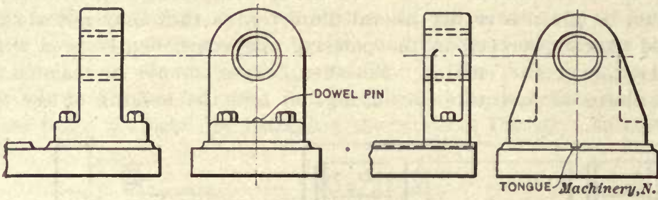
Fig. 110. Boring Jig with Base Separate from Side Standards

as shown at *D* in Fig. 109. The finished faces of these bosses are also of advantage when locating the jig against a parallel, when it is not provided with a tongue for locating purposes.

In some cases bosses are placed where measurements may be taken from the finished face to certain faces of the work, in which case the finished bosses, of course, must stand in a certain relation to the locating point; such bosses are indicated at *E*, from which measurements *B* can be taken to surfaces *G* on the work. The three lugs *H* are provided for clamping purposes, the jig being clamped in three places only to avoid unnecessary springing action. If the jig is in constant use, it would be advisable to have special clamping arrangements as component parts of the jig for clamping it to the table, thereby avoiding loss of time in finding suitable clamps.

The walls or standards *K* of large jigs of this type are frequently made in loose pieces and secured and dowelled in place as shown in

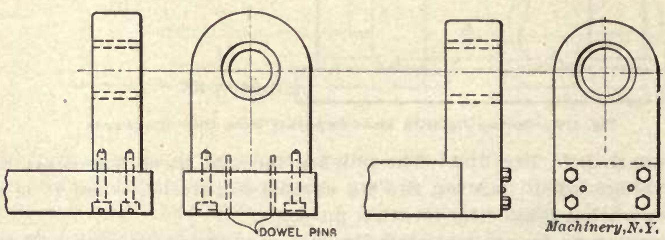
Figs. 110 to 114. In such a case the most important thing is to fasten these members firmly to the base, preventing shifting by tongues, keys, or dowels. It is evident that when the standards are made loose, as in Fig. 110, it is easier to finish the pad *A* of the base, and this is of importance, particularly when difficult locating arrangements are planed or milled in the base; the pattern-maker's and the molder's work is also simplified. As a rule the standards are screwed to the base permanently and then the bushing holes are bored. In some cases, however, it may be easier to first bore the hole in a loose part.



Figs. 111 and 112. Different Methods for Securing and Locating the Uprights on Base-plate of Boring Jig

and then attach it to the main body. Such an instance is shown in Fig. 115. It is easier to locate the bracket with the bushing *B* by working from the finished hole in connection with other important holes or locating means, than it would be to first screw the bracket in place and then expect to be able to locate the hole to be bored exactly in the center of the hub of the bracket.

When boring jigs are designed for machine parts of a similar design but of different dimensions, arrangements are often made to make one jig take various sizes. In such a case one or both standards may have



Figs. 113 and 114. Alternative Methods of Fastening Uprights to Jig Base

to be moved, and extra pads are provided on the face as illustrated in Fig. 116. This shifting of the standards will take care of different lengths of work. Should the work differ in height, a blocking piece *B* may be made as indicated in the same illustration. Sometimes special loose brackets may be more suitable for replacing the regular standards for shorter work. If there is a long distance between two bearings of the work, a third standard may be placed in between the two outside ones, if the design of the bored work permits, as shown in Fig. 117; this may then be used for shorter work together with one of the end standards. In Fig. 118 is shown another adjust-

able boring jig. Here the jig consists of two parts *A* mounted on a common base-plate or large table provided with T-slots. The work *B* is located between the standards. A number of different standards suitable for different pieces of work may be used on the same base-plate. The jigs or standards are held down on the base-plate by screws or bolts, and generally located by a tongue entering the upper part of the T-slots.

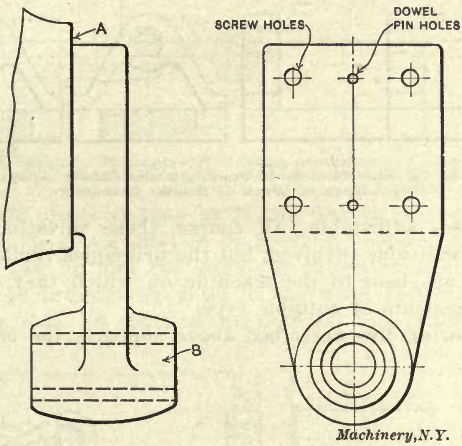


Fig. 115. A Case where the Bushing Hole is Bored Previous to Locating and Fastening Bracket on Jig Body

In the examples thus far given the work has been located on the jig, but it is apparent that boring jigs are frequently made which are located and supported on the work. Fig. 119 shows such a jig. The work *A*, which in this case represents some kind of a machine bed, has two holes bored through the walls *B* and *C*. This jig may guide the bar properly if there be but one guide bushing at *E*, but it is better if it can be arranged to carry down the jig member *D* as indi-

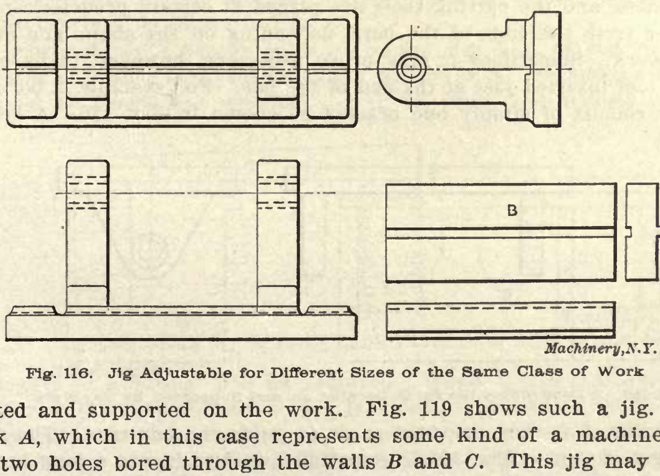


Fig. 116. Jig Adjustable for Different Sizes of the Same Class of Work

cated to give support for the bar near the wall *B*. It may sometimes be more convenient to have two separate jigs located from the same surfaces on the top or sides. In other cases it may be better to have the members *D* and *E* screwed in place instead of being solid with *F*,

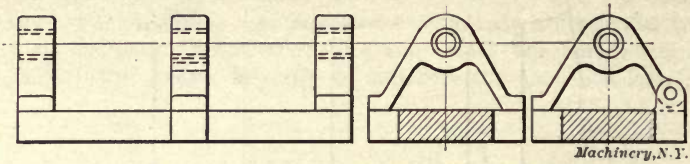


Fig. 117. Boring Jig with Removable Bearing in the Center, Adapting it to Different Sizes of Work of Similar Character

and in some cases adjustable. Of course, these variations in design depend on the conditions involved, but the principles remain the same. The jig or jigs are held to the machine on which they are used by clamping arrangements of suitable type.

The type of boring jigs described above supports the bar in two or

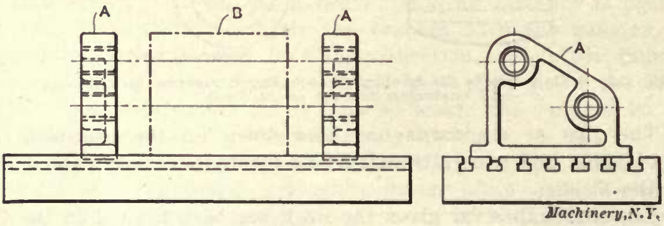


Fig. 118. Universal Base-plate for Standards of Various Descriptions for Different Classes of Work

more places, and the cutting tools are placed at certain predetermined distances from the ends of the bars, depending on the shape and size of the work. Sometimes it may prove necessary, however, to have a cutting tool inserted just at the end of the bar. For example, a boring jig may consist of simply one bracket as shown in Fig. 120. A very

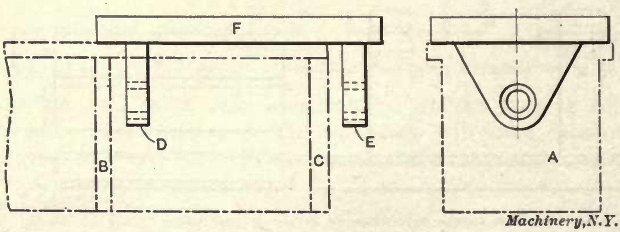
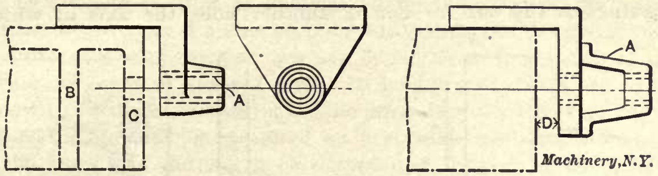


Fig. 119. A Case where the Jig is Located on and Supported by the Work

long bearing *A* is then provided so as to guide the bar true. The arrangement shown in Fig. 121 is sometimes used to insure a long bearing for the bar. A special bracket *A* is mounted on the jig and bored out at the same time as the jig proper is machined. This provides.

in effect, two bearings. In these cases bars with a cutting tool at the end are used. The reasons for using the kind of boring jig illustrated in Figs. 120 and 121 are several; in Fig. 120, for instance, there is a wall *B* immediately back of the wall *C* in which the hole is to be



Figs. 120 and 121. Examples of Guiding Arrangements where no Support is Obtainable on One Side of Hole to be Bored

bored. Other obstacles may be in the way to prevent placing a bearing on one side of the hole to be finished. Instead of having a space *D* between the jig and the work, as shown in Fig. 121, the jig can oftentimes be brought up close to the work and clamped to it from the bushing side. A combination between this latter type of jig with

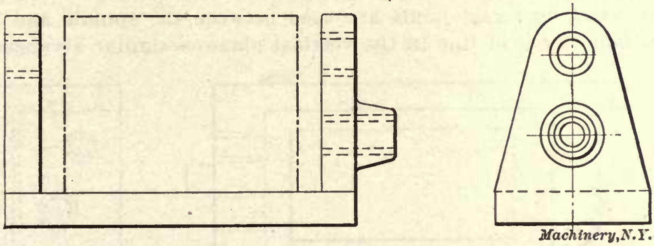


Fig. 122. Boring Jig in which One Bar has Single and One Double Bearing

but one bearing for the bar, and the type previously described with two bearings, is shown in Fig. 122.

Each of the different holes in boring jigs has, of course, its own outfit of boring bars, reamers, and facing tools. In making the jig it must be considered whether it will be used continuously and what

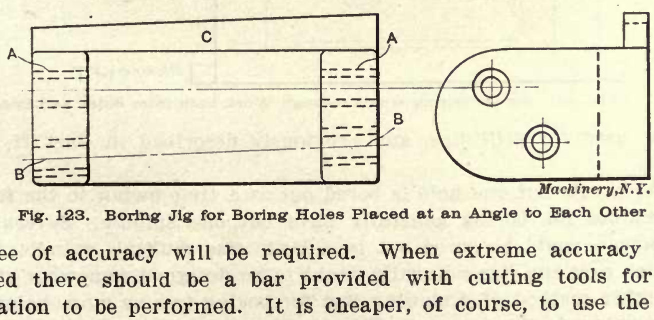


Fig. 123. Boring Jig for Boring Holes Placed at an Angle to Each Other

degree of accuracy will be required. When extreme accuracy is required there should be a bar provided with cutting tools for each operation to be performed. It is cheaper, of course, to use the same bar as far as possible for different operations and, ordinarily, satisfactory results are obtained in this way. It is desirable to have bush-

ings fitting each bar, but often this expense can be reduced by using the same bushings for bars having the same diameter.

It sometimes happens that one or more holes form an angle with the axis of other holes in the work to be bored. In the jig shown in Fig. 123 the bushings *A* guide one bar for boring one hole and the bushings *B* the bar for boring another hole, the axis of which is at

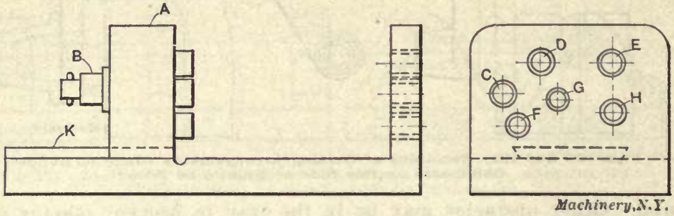


Fig. 124. Principle of Multiple Bar Boring Jig

an angle with the axis of the first hole in the horizontal plane. Then an angle plate *C* can be made in such a manner that if the jig is placed with the tapered side of plate *C* against a parallel, the hole *B* will be parallel with the spindle. This arrangement may not be necessary when universal joints are used between the spindle and the bar. If a hole is out of line in the vertical plane, a similar arrangement as

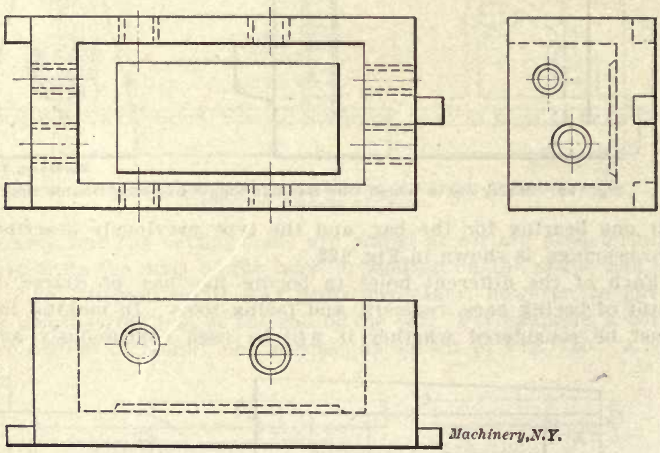


Fig. 125. Jig for Boring Holes through Work both from Sides and Ends

that used for drill jigs, and previously described in Part II, can be used.

As a rule but one hole is bored out at a time owing to the fact that machines for boring generally have but one spindle. Several holes, however, could be bored out in a large size multiple spindle drill, in which case the jigs naturally ought to be designed somewhat stronger. Another method of designing jigs for boring two or more holes at the same time is illustrated in Fig. 124, the outlines only being shown in this illustration. *A* is a gear box containing the main driving gear

which is mounted on a shaft B which in turn is driven by the spindle of the machine. The gear on shaft B drives the gears and shafts connected with the boring bars passing through the bushings C, D, E, F, G, and H. The gears are proportioned according to the speed required for each bar, which in turn is determined by the sizes of the holes. The housing or gear box A slides on a dove-tail slide K. A particularly good fit is provided, and the gear box can be fed along in relation to the work either by table or spindle feed. If boring operations are to be performed in two directions, a jig on the lines indicated in Fig. 125 is designed. This jig may be mounted on a special revolving table permitting the work and the jig to be turned and indexed so as to save resetting and readjusting the work and jig when once placed in position on the machine.

The outline given above of boring jigs illustrates only the fundamental principles involved, it being considered more important to state the fundamental principles in this connection than to describe complicated designs of tools in which the application of such principles may be more or less obscure or hidden.

CHAPTER X

BORING JIG DESIGNS*

In the previous chapter the fundamental principles of boring jigs were outlined. In the present chapter a number of applications of these principles to boring jigs that have been designed for shop use will be shown.

In Fig. 126 are shown two views of a small jig supported directly on the work to be bored. This jig is used for boring out a cross-slide carriage, and is located on the work by the dove-tail slide and held in place by the two set-screws *A*. The two bushings *B* are driven into the solid part of the jig and the two corresponding bushings *C* are placed in the loose leaf *D* which is removed when the jig is placed in position on, or removed from, the work. The two set-screws *A* do not

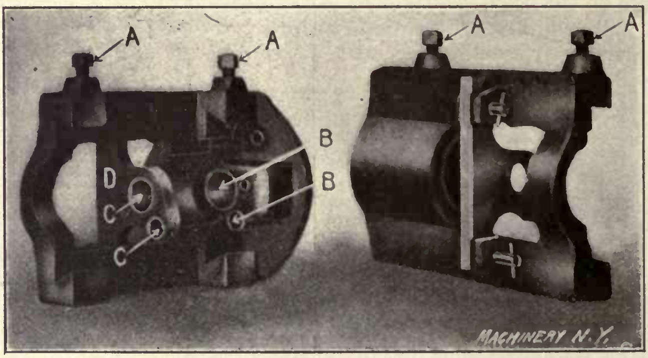


Fig. 126. Example of Small Boring Jig, with Removable Leaf for Holding Guide Bushings

bear directly on the side of the carriage, but are provided with brass or steel shoes as shown in Fig. 127, where *E* is the shoe. The leaf *D* cannot be attached permanently to the jig and simply swung out of the way when the jig is located on the work, because it could not be swung in place after the jig is applied on account of the small clearance in the cross-slide carriage. The leaf is therefore made loose, which is an objectionable feature, but lugs have been carried up on the casting on both sides of the leaf as shown, to give good support; these lugs are carefully finished to fit the leaf, and the latter is located and held in place by ground plugs.

In Fig. 128 is shown a boring jig which receives the work *A* between two uprights. The work in this case is the tail-stock of a lathe where two holes *B* and *C* are to be bored out. The bottom surface of the tail-stock is finished before boring, and is located on the finished

* MACHINERY, February, 1909.

bottom of the jig by means of a key and keyway. The keyway. is cut in the jig and is a little wider than the key in the work. and the set-screws *D* bring the key against one side of the keyway, that side being in accurate relation to the hole *B* to be bored in the tail-stock. Longitudinally the work is located by a stop pin, against which it is brought

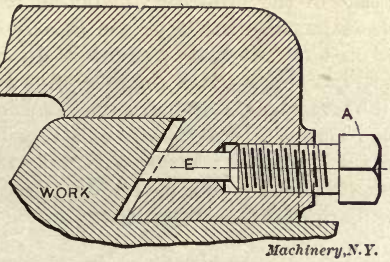


Fig. 127. Means for Holding Work against Locating Side of Dove-tail Slide of Boring Jig in Fig. 126

up by a set-screw from the opposite side. The tail-stock is held to the jig by bolts *E* exactly as it is held on the lathe bed.

The placing of the set-screws *D* at different heights is one of the features of the jig; this makes it possible for the jig to take tail-stocks of various heights for different sizes of lathes, raising blocks being used for the smaller sizes. The raising blocks are located exactly as the tail-stock itself, so that the work placed on them will come in the same relative position to the uprights of the jig whether

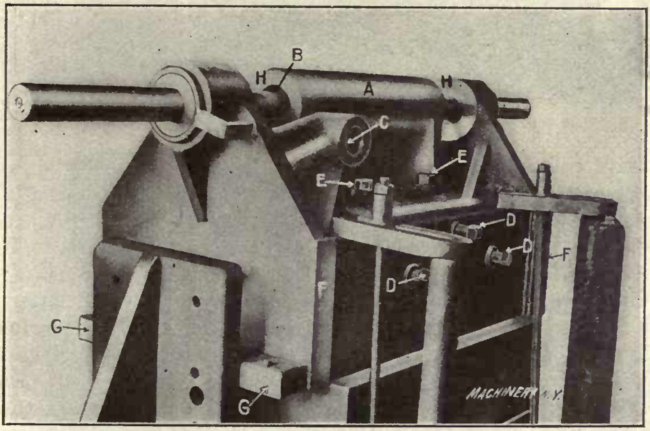


Fig. 128. Common Type of Medium Size Boring Jig

the work rests directly on the jig bottom or on the raising pieces. The two finished strips *F* are provided for facilitating the making of the jig, and the lugs *G* for the clamping down of the jig to the boring machine. The jig, however, can also be clamped to the boring machine table as shown in the illustration. At *H* is a liberal clearance between the work and jig, allowing ample room for the inserting of facing cut-

ters, reamers, and boring tools. Ribs are provided for strengthening the jig, as shown.

The half-tone Fig. 129 shows a large size boring jig made from a solid casting. In this case the work to be bored out is the head of a lathe. It is located and clamped to the jig in a way similar to that mentioned in the case of the tail-stock; clamping it to the jig in the same way that it is fastened to the lathe bed insures that the effects of possible spring will be less noticeable. Opinions differ as to whether it is good practice to make up a jig of the size shown in one piece, the distance between the standards *A* and *B* being from four to five feet, or whether it would be better to make loose members located on a base-plate as shown in Fig. 130. The writer advocates the making of one piece jigs of as large sizes as possible, because, with loose members as shown in Fig. 130, there is no assurance that the standards are located

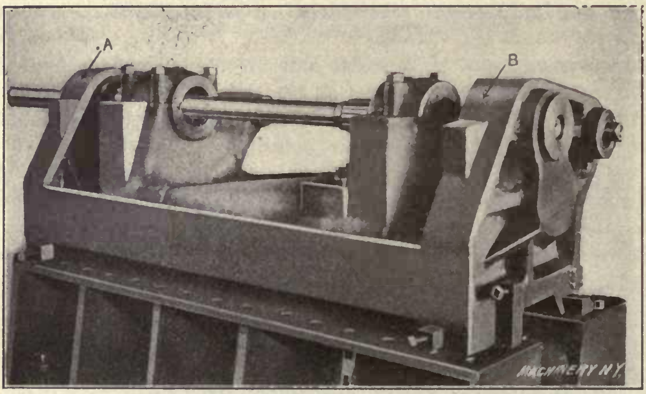


Fig. 129. Large Size Boring Jig made from a Solid Casting

correctly in relation to each other or to the work to be bored, and it involves more or less work to get the jig in order. The jig in Fig. 129 does not need to be as heavy as would be inferred from the illustration, because a large portion of the bottom can be cored out.

The boring jig illustrated in Fig. 130 consists of four parts; the upright members *A*, *B*, and *C*, and the base-plate *D*, which latter may be used for all jigs of similar construction. This type of boring jig is used only for very large work. In the case illustrated large lathe heads are to be bored. The work is located on the base-plate between the two members *A* and *C*. The member *B* is only used when the distance between *A* and *C* is very long, so that an auxiliary support for the boring bar is required, or when some obstacle prevents the bar from passing through the work from one of the outside members to the other. As a rule these members are located on the base-plate by a tongue fitting into one of the slots as shown at *E*. The members are brought as close as possible to the work, sufficient space, of course, being permitted for the cutting tools to be inserted. The standards are cored out and ribbed and lugs provided so as to give the bearing

bushings long and substantial support. Good results will be obtained with this type of jigs provided they are carefully set up on the base-plate. At *F* in the member *B* is shown a boss; this is provided with a tapped hole for a hook or eye-bolt for facilitating the moving of the jig

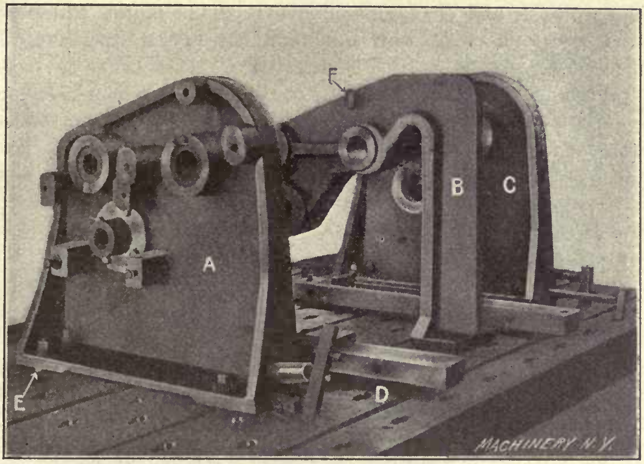


Fig. 130. Boring Jig Consisting of Base-plate and Separate Removable Uprights carrying the Guide Bushings

member by an overhead crane. The other members have tapped holes on the top for the same purpose.

The jigs in Figs. 126, 128, and 129 are ordinarily used on boring lathes, but the one shown in Fig. 130 may also be used in combination

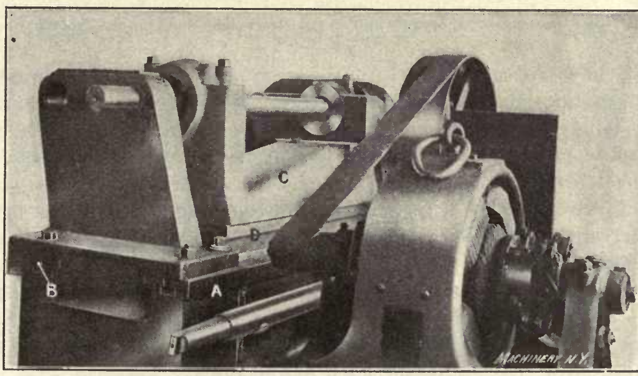


Fig. 131. Boring Jig with Portable Drive

with a portable driving and feeding arrangement, one type of which is shown in Fig. 132. The lugs and finished bosses on the side of jig member *A*, which do not carry bushings, are used for connection to this drive and feed mechanism.

Fig. 131 shows a boring jig of the loose member type provided with

motor drive for the boring bars. The members are mounted on the base *A*, located by the tongue *B*, and clamped down by T-bolts. The work *C*, a lathe head, is placed on the extension piece *D*. The boring bar is driven from the motor by means of a worm and worm-wheel, the bar being fed along as shown in Fig. 132. In this engraving, *A* represents the work, *B* and *C* the jig members, *D* the motor which is belt-connected to the pulley *E*, which, in turn, through a worm-shaft *F* and the worm-wheel *W*, drives the boring bar *G*; this latter is keyed to, but at the same time is a sliding fit in, the worm-wheel. The bar is fed forward by the feed-screw *H* which passes through the stationary nut *J* fastened to the base-plate. The motion of the screw is actuated from the bar itself through a train of gears. The gear *K* is keyed to the screw and driven by the gear *L* which is mounted on the same stud as the star-wheel *M* which is turned by the pin *N* attached to the connecting head *O*; this latter rotates with the boring bar, but the

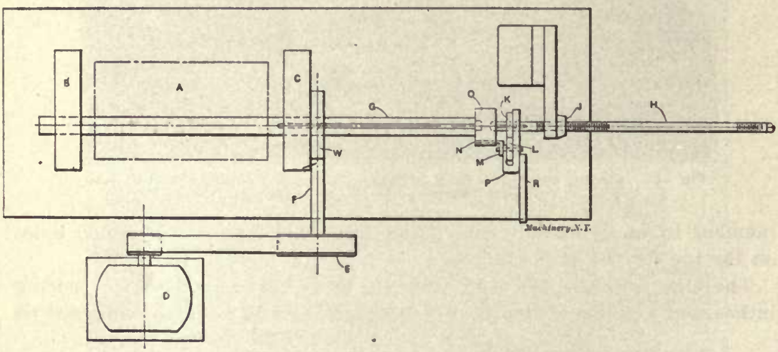


Fig. 132. Outline of Arrangement of the Drive and Feed of the Boring Bar of the Jig in Fig. 131

screw *H* is a free-running fit in *O*, and simply has a thrust washer at its end to take the feed thrust. More or less feed can be arranged for by using more than one pin in the connecting head. The pin or pins can be pulled back when the feed is not required. The gears and star-wheel are mounted in the bracket *P* which follows the bar and which is prevented from turning by the rod *R* fastened to the bracket. The bar can be pushed back by using a wrench or crank at the end of the feed-screw.

The feed arrangement shown has proved very serviceable and reliable. A separate and portable drive, of the type indicated, is quite necessary for large boring jigs as there are few machines large enough in the ordinary shop to handle such heavy work.

In Fig. 133 is shown a boring jig for boring out the top frame *A* of radial drills. The design of the jig is simple but effective; the hole *B* is parallel with the finished side *C* of the jig and is bored out after the jig has been brought up square against a parallel and strapped to the machine table. The hole *D* is bored at an angle with the hole *B*, and the setting of the jig for the boring out of this hole is facilitated

by providing a wedge-shaped piece *E* of such an angle that the jig will be set in the proper position when moved up against the wedge. If universal joints are used for connecting the boring bar with the driving spindle, the setting of the work at an angle could be omitted, although it is preferable even when using universal joints to have the boring

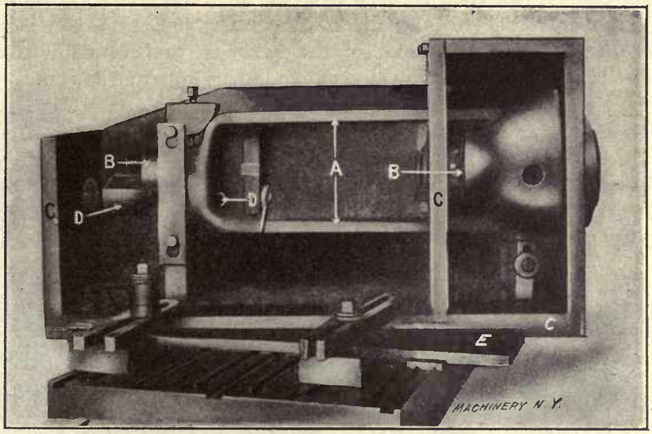


Fig. 133. Wedge-piece for Aligning Work for Boring Holes with the Axes at an Angle

bars as nearly as possible in line with the spindle. This eliminates a great deal of the eccentric stress, especially when taking a heavy cut with coarse feed.

Boring operations are sometimes carried out using parts of the machine itself as guiding means for the boring bars, and in some

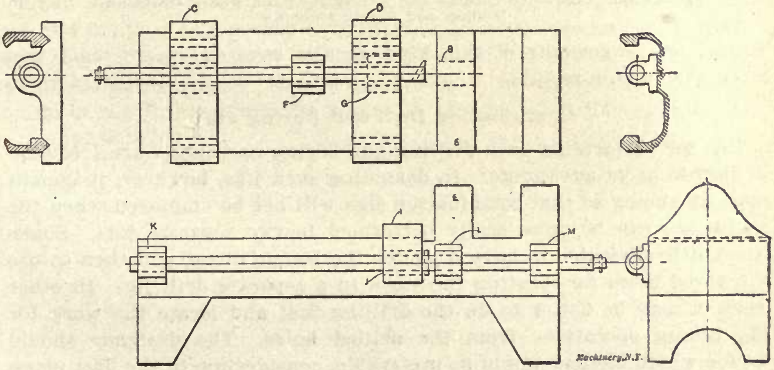


Fig. 134. Examples of Boring where Parts of the Machine being Built are Used as Guiding Means

instances it is very essential that boring operations be performed in this way in order to obtain perfect alignment. In Fig. 134 is shown a line engraving of a machine bed with the head-stock solid with the bed. In the top view is shown a method for boring out a hole at *B* by the

use of two jigs *C* and *D* which are located on the V's of the machine and held down by hook bolts. If the hole *B* only passes through the part *E* of the head this would be the preferable way of boring it. In some instances, however, the hole *B* may be required to be in alignment with the holes in a carriage or in a bracket as at *F* and *G*. These holes, of course, can then be used to great advantage as guiding means. Should the holes be too large to fit the boring bar, cast-iron bushings can be made to fit the holes and the bar. In the elevation and end view of Fig. 134 is shown how a cross-slide carriage and apron *I*, which has a hole *J* in line with the holes in bearings *K*, *L*, and *M*, and travels between *K* and *L*, can be bored out by using the brackets *K*, *L*, and *M* to guide the boring bar. By keying the traveling part *I* close to the bracket during the boring operation, as illustrated, accurate results will be obtained. It is evident that two of the bearings could be bored out by using the finished bearing and the traveling part *I* as guiding

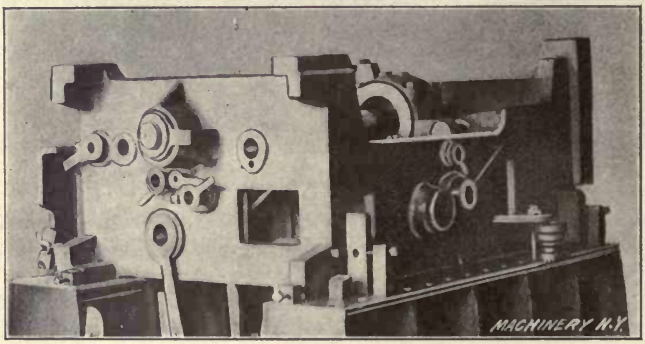


Fig. 135. Combined Drilling and Boring Jig Used with a Horizontal Drilling and Boring Machine

means. Arrangements of this kind usually save expensive tools, and often give better results.

Combination Drill and Boring Jig

Jigs for performing both drilling and boring operations are frequently used to great advantage. In designing such jigs, however, judgment must be shown so that combination jigs will not be employed when the operations can be more easily performed in two separate jigs. Sometimes it is advisable to have a jig for the boring alone, and then to use the bored holes for locating the work in a separate drill jig. In other cases it may be better to do the drilling first and locate the work for the boring operations from the drilled holes. The designer should decide which method would be preferable, considering, in the first place, the factors of the time required and the accuracy of the work. To give any definite rules for this work is not possible; but it may be said that combination jigs should be used only when the drilled and bored holes have nearly the same diameters. When the holes are of widely different diameters two jigs are preferable. If a few screw-holes of small diameter for holding a collar or bracket, for instance, located

around a large bored hole, were to be drilled with the same jig used for the large hole, the jig, when used on a small drill press, would be entirely too heavy to manipulate. It is likely that in such a case a small separate drill jig could be attached directly to the work. In other cases, however, it will prove a distinct saving to combine the boring and drilling jig in one.

In Figs. 135 and 136 is shown a combination drill and boring jig of large size. The work *A* in Fig. 136 is a head-stock for a lathe with a

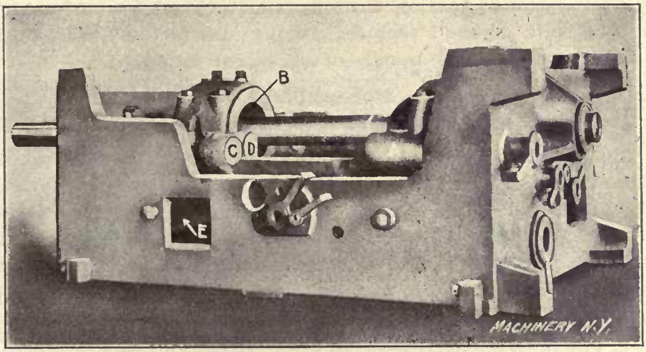


Fig. 136. Another View of the Jig in Fig. 135. Note that Holes are Drilled or Bored from All Sides

number of holes to be drilled. The large holes *B* at both ends of the head-stock are cored as usual, and allow the boring bar to enter for taking the roughing cut. The holes at *C* and *D* are opened up by drills previous to the boring operation. As there is considerable distance between the end of the head-stock and the uprights of the jig, long bushings are used to give the tools a good bearing close to the work. Both the drilling and boring operations may be performed on a horizontal boring and drilling machine. As the horizontal boring and drilling machines usually have adjustments in all directions, the only moving of the jig necessary is to turn it around for drilling the holes on the opposite sides.

CHAPTER XI

BORING, REAMING AND FACING TOOLS*

More or less elaborate tools or sets of tools are required for the various boring operations performed with or without boring jigs. These tools comprise boring, reaming and facing bars, boring and facing cutters, solid or shell reamers, boring and facing heads, bushings, stops, drills, collets, and knuckle or universal joints.

Boring Bars

The general requirements of a boring bar are that it must be as heavy and rigid as possible, straight, and ground concentric, and a good running fit in the bushings. When the bar has been turned and once ground to the right size, it should never be put in a lathe and filed, or emery cloth used on it. Boring bars are made from machine steel and are not hardened. Sometimes small bars are made from tool steel and hardened, in order to give them additional stiffness. Shanks for reamers, and facing bars, should be made in the same way as boring bars, but if possible, should be even stiffer.

The most common type of boring bar is shown in Fig. 137, the cutter *A* being located about at the middle of the bar, and the bar being guided at both ends by bushings *B* and *C*. The bar is provided with a taper shank at *D*, fitting the spindle of the machine or a collet connected with a knuckle joint. It is quite common practice to turn down the end of the bar, as shown in Fig. 138, to fit a knuckle joint or the collet shown in Fig. 141. Sometimes, of course, the bar can be left full size, as shown in Fig. 139, and sometimes the end is even made larger than the bar, by forcing on a collar, as shown in Fig. 140, in order that the end may fit the driving collet. A key is passed through the end of the bar for driving it; this key fits in the slot *A* in the collet shown in Fig. 141.

The bar shown in Fig. 137 can also be used for facing purposes, the cutter *A* being taken out, and a facing cutter inserted. The same bar can also be used for a special shell reamer, when this has a straight hole, the reamer being held to the bar by a taper pin, as shown in Fig. 142. Standard shell reamers have a taper hole, and for these, the bar must be turned with a taper part, as shown in Fig. 143, where the part *A* is turned up to the largest size possible (generally 1/32 or 1/16 inch under the diameter of the reamer); part *B*, being turned to fit the taper hole in the shell reamer, is left long enough to permit the reamer being pressed up tight without touching the shoulder *D*. As a rule, the taper part is so dimensioned that ⅛ inch will be left at *E*, between the shoulder of the bar and the back of the shell reamer, when this is forced up as far as possible. The reamer is driven by keys or pins entering in a slot cut across the end of the reamer. The

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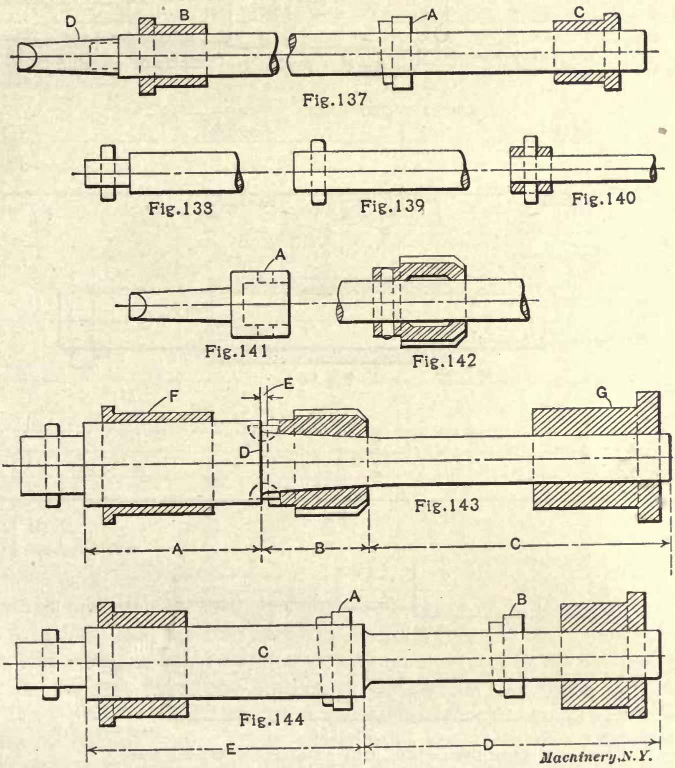
* MACHINERY, March, 1909.

part *C* of the bar is turned down to some standard size, just below the size of the small end of the taper hole in the reamer. The bushings *F* and *G* may be made with the same outside diameter, fitting the same size lining bushings in the jig, their inside bearings being made to fit the large and small diameters of the bar.

A boring bar used for boring out two holes of different sizes may be made as shown in Fig. 144; *A* and *B* are the cutters for the two holes, and part of the bar *C* is turned down for a length *D*, to fit the small hole. The part *E* can then be made of as large diameter as

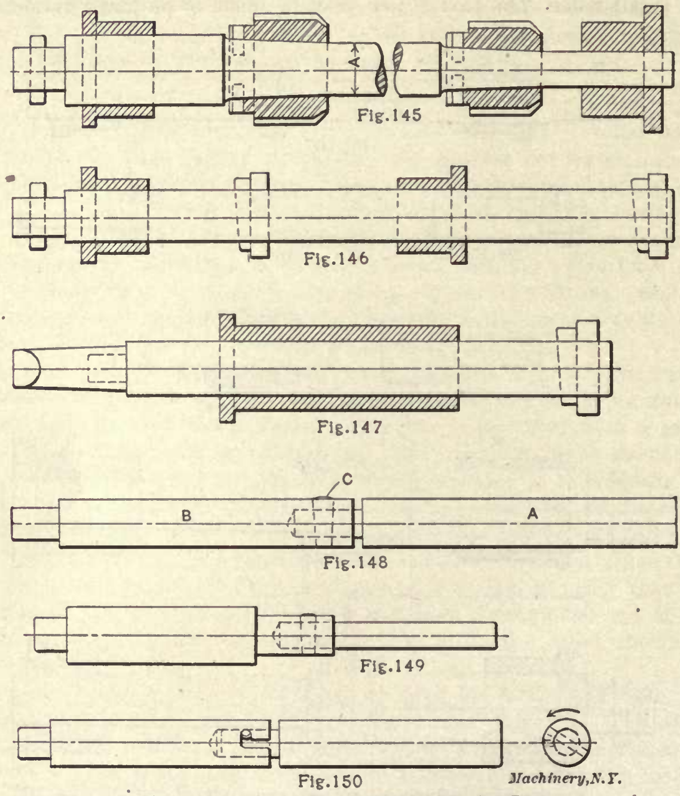


Figs. 137 to 144. Boring Bars of Different Types

permissible for boring out the hole for which tool *A* is used. By making the bar in this way, a more rigid construction is possible than if the part *E* were turned down to the smaller diameter required by the hole bored by cutter *B*. There may be more than two holes of different sizes in succession,and then the bars may have a greater number of steps; if there is but a slight difference in the sizes of the holes to be bored out, it hardly pays to turn down steps on the bar. The stepped bar may also be used for facing bars. While these small matters may seem unimportant and elementary, they must be taken

into consideration when designing a set of expensive tools for boring jigs which are to be in constant use.

Reamer bars used for reaming out two or more holes simultaneously may be made as shown in Fig. 145, providing the diameter *A* is large enough for turning the taper portion for another shell reamer of smaller size. Should the diameter be too small to permit this, an extension can be provided, or a separate bar used for the smaller reamer. The principle of stepped bars can be applied also in cases



Figs. 145 to 150. Other Designs of Boring Bars

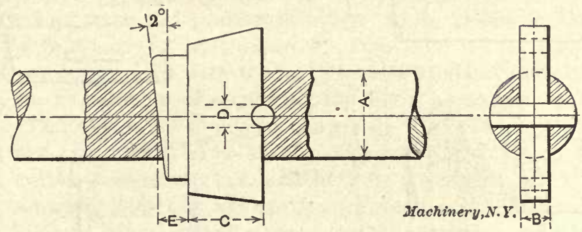
where the cutters are placed as illustrated in Fig. 146. Here one boring cutter or facing tool is placed at one end, the bar still being guided by two bushings.

A boring, facing, and reamer bar used almost as commonly as the one already described, is illustrated in Fig. 147. The principal features of this bar are that the cutting tool is always located at the end of the bar, opposite where it is driven, and that there is but one bushing for guiding. This bushing should be as long as possible to give a good bearing and prevent the bar from wabbling. Sometimes, as illustrated in Fig. 121, the jig is made with two bearings which,

however, are on the same side of the cutter, and a comparatively short distance apart.

Sometimes a bar must be made in two parts. The reason may be that one solid bar would be too long to permit its being pushed into the jig from one side. Another reason may be that the cutting tools are too large to pass through some intermediate hole. The two parts of the bar may be connected with a taper pin, as shown in Fig. 148, the end of bar *A* being a sliding or driving fit in the hole in section *B*. This bar should be ground after the two parts are assembled, so that they will run exactly true with each other. A stepped bar made up of two sections is shown in Fig. 149. In Fig. 150, another method of connecting the two sections is shown; when this method is used the two bars can be put together and taken apart very rapidly.

TABLE X. BORING AND FACING CUTTERS



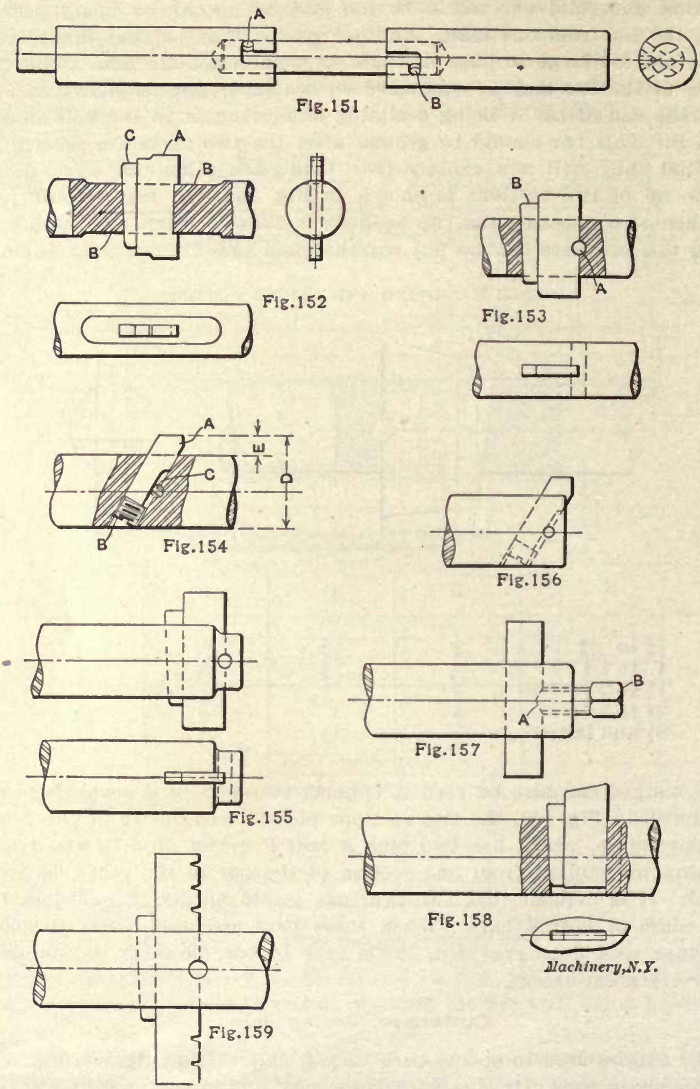
A	B	C	D	E
$\frac{3}{4}$ to $\frac{15}{16}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{16}$	$\frac{1}{4}$
1 to $1\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{4}$	$\frac{3}{16}$	$\frac{1}{4}$
$1\frac{1}{2}$ to $2\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
$2\frac{1}{2}$ to 3	$\frac{1}{2}$	1	$\frac{1}{4}$	$\frac{5}{16}$
$3\frac{1}{8}$ and larger	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$

This method can also be used to connect two bars by a separate piece, as shown in Fig. 151, the two sections being bored out to fit the intermediate piece, which has two pins *A* and *B* driven into it, and transmitting the motion from one section of the bar to the other, as indicated. It is evident that two bearings would hardly be sufficient for this class of boring bars. When these bars are used, three or more bearings should be provided. This type of bar, however, is not used to a very great extent.

Cutters for Boring Bars

The cutters used in boring bars vary widely. The cutter *A*, Fig. 152, is commonly used. It cuts with both ends, and is centered by the two flats *B*, milled or filed on the bar; a slot is provided in the cutter, which fits these flats of the bar. After the cutter has been put in place, it is tightened by the key *C*, and is turned to the correct diameter required, and then hardened. A more modern arrangement is shown in Fig. 153. The cutter here is a plain rectangular piece of

steel, cutting with both ends. It is centered by the pin *A*, which is driven into a hole drilled so that one-half of it passes through the slot in the cutter. As in the former case, the cutter is turned down to the



Figs. 151 to 159. Different Types of Cutters and Methods of Fastening

right diameter when in place. It is tightened down by the key *B*. This way of locating the cutter centrally has proved very satisfactory. In Table X are given dimensions of cutters for different bar diameters.

Facing cutters may be located and held in place in the same way.

They are longer than boring cutters, being intended to finish a boss or seat around a hole, but otherwise they are made to about the same dimensions.

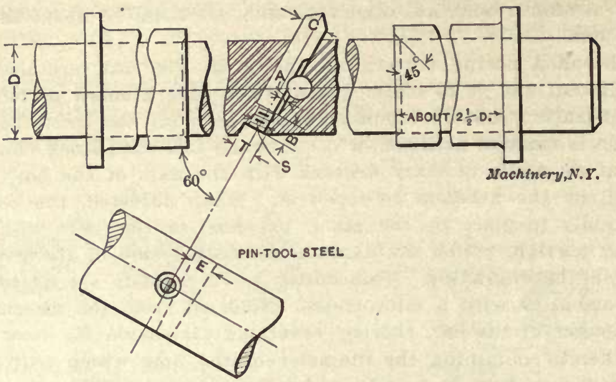
Single-ended boring cutters, as shown in Fig. 154, are used to a great extent, and it is claimed that they give a more perfect hole. The illustration shows a common way of securing the tool; the cutter *A*, which is made of drill rod or other round tool steel stock, fits a hole bored at an angle of sixty degrees with the axis of the bar, and is adjusted by the headless set-screw *B*. When adjusted, the cutter is held rigidly in place by the pin *C* provided on one side with a flat tapering portion, which fits against the flatted side of the cutter, as shown in the engraving. This cutter is very easily set by taking a measurement *D* with a micrometer. Subtract from the dimension *D* the diameter of the bar, thereby obtaining dimension *E*. Now add *E* to *D*, thereby obtaining the diameter of the hole which will be cut. The screw may have to be adjusted a few times, to obtain the desired result. Table XI gives dimensions for this kind of cutters, and also for screws and pins used with them. The two kinds of cutters referred to may also be used on the ends of the bars, as shown in Figs. 155 and 156. The cutter of the type shown in Fig. 153 may be held in either of the two ways shown in Fig. 155 and Fig. 157. In the latter case, the cutter is spotted at *A*, and held by a pointed screw *B*. This method, however, does not always insure very accurate results. The simplest kind of single-ended cutter, and the manner in which it is held is shown in Fig. 158. It may be used in any kind of bar, and with ordinary care, good results may be obtained even with this simple tool. The variations possible are many, and the examples shown simply indicate the most common practice.

Facing cutters may be made similar to boring tools, or they may be made with teeth, like end milling cutters, as illustrated in Fig. 161. In this engraving, one of the cutters *A* cuts with both sides, while the cutter *B* cuts with one side only. The bar is provided with a slot and with notches for locating and holding in place the various cutters, as shown at *C*. A pin *D* is driven into the cutter, and enters the notch, thus driving the tool. The cutters can also be held on the bar by taper pins, but the putting in place and the removal of the cutters would then be much slower.

Different cutters are commonly used for roughing and finishing. To make it easier to remove the metal with the roughing cutter, it may be made with every other tooth beveled in opposite directions, as shown in Fig. 160, where *A* is one tooth beveled toward the center, and *B* the next tooth beveled outward. Using a cutter of this kind will produce a surface as indicated at *C*, which must be faced square by a finishing cutter.

In order to face the work to correct dimensions, stops are sometimes provided which strike against some finished surface on the jig which stands in a given relation to the finished surface on the work and the cutting edge of the facing cutter. Such a stop may be made as shown at *E* in Fig. 161, and be held and located in the same way

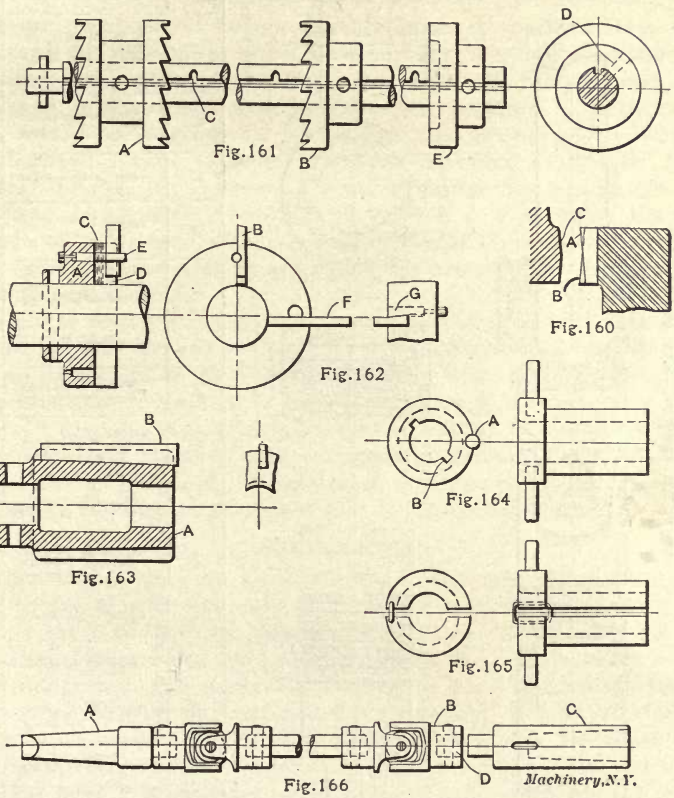
TABLE XI. BORING-BAR CUTTERS



D	C	E	A	S	T	B
Diameter of Bar.	Diameter of Cutter.	Diameter of Pin.	Depth of Milled Down Part.	Diameter of Screw.	Diameter of Counter-bore.	Length of Thread.
$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{5}{64}$
$\frac{7}{16}$	$\frac{1}{8}$	$\frac{3}{32}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{5}{64}$
$\frac{1}{2}$	$\frac{1}{8}$	$\frac{3}{32}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{5}{64}$
$\frac{9}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{1}{8}$
$\frac{5}{8}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{1}{8}$
$\frac{11}{16}$	$\frac{3}{16}$	$\frac{5}{32}$	$\frac{1}{32}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{5}{32}$
$\frac{3}{4}$	$\frac{3}{16}$	$\frac{5}{32}$	$\frac{1}{32}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{5}{32}$
$\frac{13}{16}$	$\frac{1}{4}$	$\frac{5}{32}$	$\frac{1}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
$\frac{7}{8}$	$\frac{1}{4}$	$\frac{5}{32}$	$\frac{1}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
$\frac{15}{16}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$
1	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$
$1\frac{1}{8}$	$\frac{5}{16}$	$\frac{7}{32}$	$\frac{1}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$
$1\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{3}{64}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$
$1\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{64}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$
$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{9}{32}$	$\frac{3}{64}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$
$1\frac{5}{8}$	$\frac{7}{16}$	$\frac{5}{16}$	$\frac{3}{64}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$
$1\frac{3}{4}$	$\frac{7}{16}$	$\frac{5}{16}$	$\frac{3}{64}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
$1\frac{7}{8}$	$\frac{1}{2}$	$\frac{11}{32}$	$\frac{1}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
2	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$
$2\frac{1}{8}$	$\frac{9}{16}$	$\frac{13}{32}$	$\frac{1}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$
$2\frac{1}{4}$	$\frac{9}{16}$	$\frac{13}{32}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$
$2\frac{3}{8}$	$\frac{5}{8}$	$\frac{7}{16}$	$\frac{5}{64}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$
$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{15}{32}$	$\frac{5}{64}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$
$2\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{2}$	$\frac{5}{64}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$
$2\frac{3}{4}$	$\frac{11}{16}$	$\frac{1}{2}$	$\frac{5}{64}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$
$2\frac{7}{8}$	$\frac{3}{4}$	$\frac{17}{32}$	$\frac{3}{32}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
3	$\frac{3}{4}$	$\frac{9}{16}$	$\frac{3}{32}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$

as the facing cutter. The stops are made of machine steel, case-hardened, and ground on the bearing surface. When facing up a wide surface with an inserted blade facing tool, it is often the practice to cut small notches in the blade, as shown in Fig. 159, the cutting edges on the one end overlapping the notches on the other. Very often

the holes to be bored are too large to permit cutters, such as previously described, being used, and then it is necessary to provide the boring bars with a boring head. A simple boring head is illustrated in Fig. 162, in which *A* is the head held on the bar by a taper pin; *B* is a boring tool which fits in a slot in the head, and which can be adjusted out and in by the screw *C*, passing through the shoe *D* which, in turn, fits the slot, and against which the cutter is located, as illustrated. The cutter and shoe are held by the bolt *E*. The bolt is milled flat on one side so that a hook is formed for binding the cutter

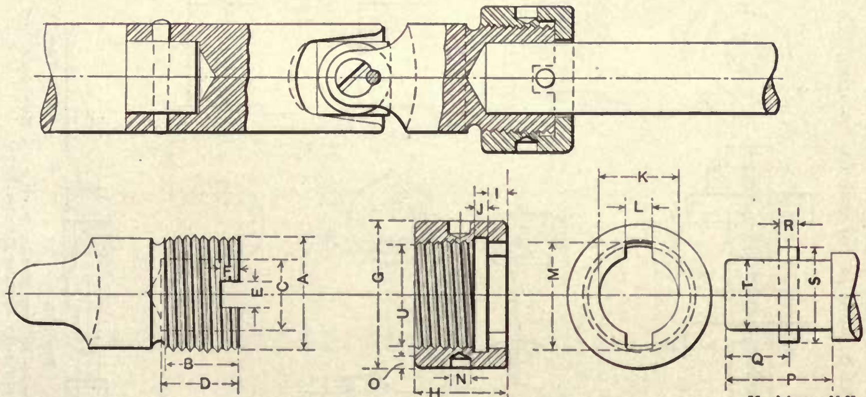


Figs. 160 to 166. Facing Tools, Boring Heads, Boring Jig Bushings, and Universal Joints for Driving Boring Bars

and shoe. Two or more cutters may be used in these boring heads. At *F*, in Fig. 162, is shown a facing tool used in the same head as the boring tool. No adjusting shoe is necessary in this case, as the facing cutter bears directly against the bottom of the slot in the head, and against the boring bar, and is held by a bolt *G*, milled with a tapering flat on one side, which wedges the cutter into its seat. More complicated boring heads are provided with a small slide for adjusting the tools; some are made similar to the box tools used in turret lathes.

The reamers most commonly used in connection with boring jigs

TABLE XII. BORING-BAR COUPLINGS



Machinery, N.Y.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U, Bore.	Threads per inch.	Used for Bars.
$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{5}{32}$	1	$\frac{5}{8}$	$\frac{1}{8}$	$\frac{3}{32}$	$\frac{17}{32}$	$\frac{3}{16}$	$\frac{11}{16}$	$\frac{9}{64}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{21}{32}$	0.499	0.6610	16	$\frac{3}{8}$ to $\frac{1}{2}$
1	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{7}{32}$	$1\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{32}$	$\frac{3}{32}$	$\frac{21}{32}$	$\frac{1}{4}$	$\frac{15}{16}$	$\frac{11}{64}$	$\frac{5}{32}$	$\frac{7}{8}$	$\frac{15}{32}$	$\frac{3}{16}$	$\frac{7}{8}$	0.624	0.9110	16	$\frac{1}{2}$ to $\frac{3}{4}$
$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{9}{32}$	$1\frac{5}{8}$	$\frac{13}{16}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{25}{32}$	$\frac{5}{16}$	$1\frac{5}{32}$	$\frac{13}{64}$	$\frac{5}{32}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$1\frac{1}{16}$	0.749	1.1615	12	$\frac{3}{4}$ to 1
$1\frac{1}{2}$	$\frac{13}{16}$	1	$\frac{7}{8}$	$\frac{7}{16}$	$\frac{13}{32}$	2	$1\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{1}{32}$	$\frac{7}{16}$	$1\frac{13}{32}$	$\frac{15}{64}$	$\frac{7}{32}$	$1\frac{3}{8}$	$\frac{11}{16}$	$\frac{3}{8}$	$1\frac{5}{16}$	0.999	1.4115	12	1 to $1\frac{1}{2}$
$2\frac{1}{2}$	$\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$\frac{9}{16}$	$\frac{17}{32}$	3	$1\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{17}{32}$	$\frac{9}{16}$	$2\frac{3}{8}$	$\frac{19}{64}$	$\frac{7}{32}$	$1\frac{7}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$2\frac{1}{4}$	1.4985	2.4115	12	$1\frac{1}{2}$ to 2
3	$\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{3}{4}$	$\frac{11}{16}$	$\frac{21}{32}$	$3\frac{1}{2}$	$1\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{29}{32}$	$\frac{11}{16}$	$2\frac{7}{8}$	$\frac{21}{64}$	$\frac{7}{32}$	$2\frac{5}{16}$	$1\frac{7}{16}$	$\frac{5}{8}$	$2\frac{3}{4}$	1.8735	2.9115	12	2 and over

are shell reamers of standard make. Many concerns have been in the habit of making their own shell reamers with inserted blades, designed about as shown in Fig. 163; *A* is a machine steel body, and *B* a tool steel blade, which is made tapered as shown, and driven into place. When the blades are inserted in the body, the reamer is ground. The reamer can be re-ground when dull, and kept to standard size, by forcing up the blades along the taper. The bodies of very large inserted blade reamers are made of cast iron.

Bushings for Boring Jigs

Lining bushings for boring jigs are made of machine steel, case-hardened and ground, and the loose bushings also are often made of machine steel. They may, however, be made with equal success from cast iron, which wears well, and has less tendency to stick to the steel bar. The bushings for boring jigs may be made with facilities for removal, similar to those previously described in Chapter II, of Part I. In Fig. 164 is shown a bushing having two pins driven into the head, to facilitate removal, and the pin *A* over which the half-round slot in the edge of the head fits, prevents the bushing from turning. Slots, as shown at *B*, are sometimes provided to permit cutting tools to pass through.

In places where it is impossible to put in bushings before the bar is put in, or over the end of the bar after it is put in, a bushing made in two halves can be used, as illustrated in Fig. 165. The writer has seen this kind of bushing in use in the Pratt & Whitney Co.'s shops, where it probably was originated, and it worked very well. The two halves are held together by a wire passing through the head flanges at one side as indicated. A bushing of this type can be put right over the bar at any place, and pushed into the lining bushing.

Knuckle Joints

When boring bars are provided with a standard taper shank, this may be put directly into the spindle of the machine, but in that case the jig must be lined up very accurately with the spindle, and this sometimes takes more time than is permissible. It is better to use knuckle or universal joints for connecting the live spindle with the boring bar. These are constructed as indicated in Fig. 166, and are made in different sizes, for the different sized bars for which they are used. The shank *A* fits into the machine spindle. The end of the knuckle joint *B* is provided with a hole *D* into which fits the end of the collet *C*, which in turn, takes the shank of the boring bar. The hole *D* may also take the end of the boring bars directly. The method of driving the bar from the knuckle joint may be either by a taper pin as shown in Fig. 166, or by the means shown in the engraving in Table XII, where dimensions are given for a coupling of good construction, connecting boring bar and knuckle joint.

CHAPTER XII

PLANING AND MILLING FIXTURES*

Fixtures for planing and milling are as essential for interchangeable manufacturing as are drilling and boring jigs. Fixtures of this kind serve primarily the purpose of locating and holding the work, but they are often provided with setting pieces or templets which are made either in one part with the fixture or separate; the cutting tools are set to these setting pieces so that the work is always machined in a certain relation to the locating means on the fixture itself.

When more than one milling operation is to be performed on the same piece, it is often possible to use the same fixture for the various operations, but it may be, in some cases, of advantage to make up a fixture for each different operation. The designer must in this case be guided by the number of pieces that are to be machined, and the advantages as regards rapidity of handling and operation that may be gained by having special fixtures for every operation, even though the operations may be such as to permit the same fixture to be used, with or without slight changes.

The strength of fixtures should be governed by the kind of operation to be carried out on the work while in the fixture, whether planing, milling, slotting, etc., and how much stock is to be removed. A milling fixture, as a rule, must be made stronger than a planing fixture, because a milling cutter, as a rule, takes a heavier cut than a planing tool.

The principles which have been previously explained in this treatise for drill jigs govern the locating means of milling fixtures, and clamping devices of the same general type are described and illustrated in Chapter IV, are used, except that they are usually made heavier than when used for drill jigs and planing fixtures. On account of the irregular form of the work and the necessity for clearing the cutting tools, the clamps of milling and planing fixtures must often have irregular shapes.

An important factor, on which too much stress cannot be placed, is the necessity of having sufficient clearance for the cutting tools so that they will not interfere with some part of the fixture and clamping devices, and also that the fixtures, when located on the platen or machine table, will not interfere with any part of the machine, when the table is fed one way or another. As a rule, milling and planing fixtures are provided with a tongue or key in the base, for locating them on the machine table. Suitable lugs should also be provided for clamping the fixture to the platen.

One of the very simplest types of fixture is illustrated in Fig. 167; work being planed is very commonly located and held by the means indicated, and for taking light cuts in the milling machine such an

* MACHINERY, April, 1909.

appliance may also be used. In this case, the planer platen *A* forms part of the fixture, and the work *B*, located on the platen, is held up against the bar *C*, which is held down by bolts, and located by a tongue as shown. The lugs and lug-screws shown with the spurs *D* hold the work up against the bar, and press it flat against the table. Instead of using the loose spurs *D* between the screws and the work, it is sometimes possible to let the screws bear directly on the work, in which case the screws should pass through the lugs at an angle with the top of the table, as shown in Fig. 173. The arrangement in Fig. 167 may or may not properly be considered a fixture, but it illustrates the

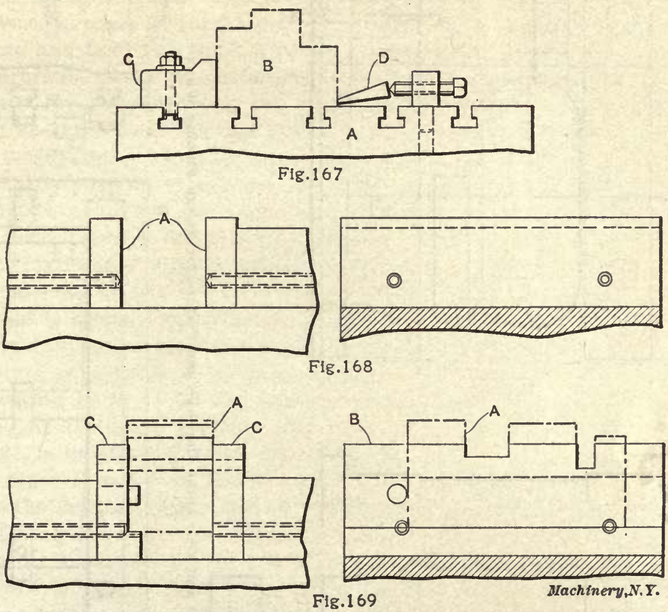
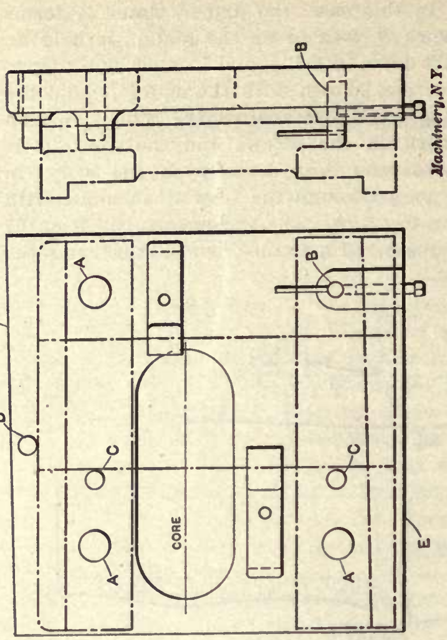
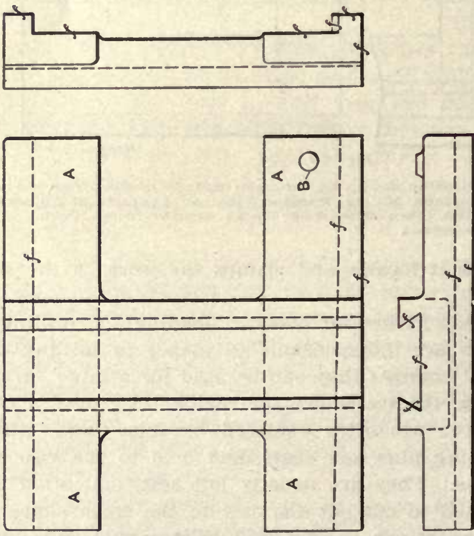


Fig. 167. Principles of Fixtures as shown by Common Method of Clamping Work on the Planer. Fig. 168. The Common Milling Machine Vise, an Example of Adjustable Fixture of Wide Range. Fig. 169. Vise with False Jaws shaped to the Form of the Work by the Cutting Tools themselves

principles of a fixture, as it locates and clamps the work in the simplest manner.

The most commonly used fixture for planing, shaping and milling is the vise. Standard vises are indispensable in planer or milling machine work, and by slight changes they can be used for a large variety of smaller pieces. In Fig. 168 are shown the regular vise jaws *A* of a standard vise. These jaws are often replaced by false jaws, which may be fitted with locating pins and seats, and held to the vise the same as the regular jaws. They are usually left soft, and often the milling cutter is permitted to cut out the jaw to the same shape as required for the work, as shown in Fig. 169. Vises with false vise jaws are especially adapted for milling operations, but vises are not usually employed for long work, special fixtures then being commonly





Figs. 170 and 171. Lathe Carriage and Fixture for Rough Planing Ways

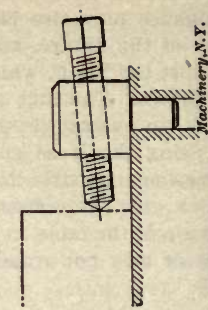
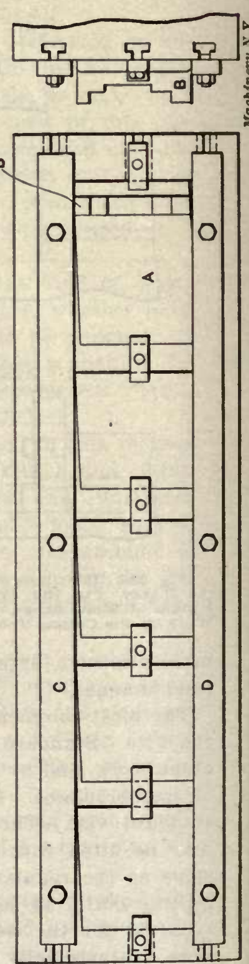


Fig. 173. Clamping Work by Means of Pointed Screw



made. While it is difficult to lay down specific principles for the designing of milling and planing fixtures, it may be said that for most kinds of plain work, finished in the planer, the fixture shown in Fig. 167 is quite satisfactory. When pieces of a more complicated nature are to be machined, particularly in the milling machine, more complicated fixtures will be required.

Assume that a set of planing fixtures for the piece shown in Fig. 170 is required. The work is a slide or carriage for a lathe. The finishing marks given on a number of the surfaces indicate where the work is to be finished. The piece comes from the foundry. In the first place, it must be considered from which sides to locate, and how to locate and hold the work without springing it, and in what order the operations should be performed to best advantage. Fig. 171 shows a fixture for roughing out the ways on the bottom. The slide is located on three fixed locating points *A* and the sliding point *B*. This latter is adjustable in order to enable cutting the metal in the slide as nearly as possible to uniform thickness. Sometimes, if the parts *A*, Fig. 170, bevel toward the ends, lugs *B* may be added; these can then be finished and used for locating purposes. The carriage, as shown in Fig. 171, is further located against the pins *C* in order to insure that the cross-slide of the carriage will be square with the bottom ways. The slide is brought up sidewise against the pin *D*, and then clamped down in convenient places, the clamps being placed as near the bearing points as possible to avoid springing. The reason for not having the locating point *D* on the opposite side, is that this side must be finished at the same setting; this side, being the front side of the carriage, is finished for receiving an apron.

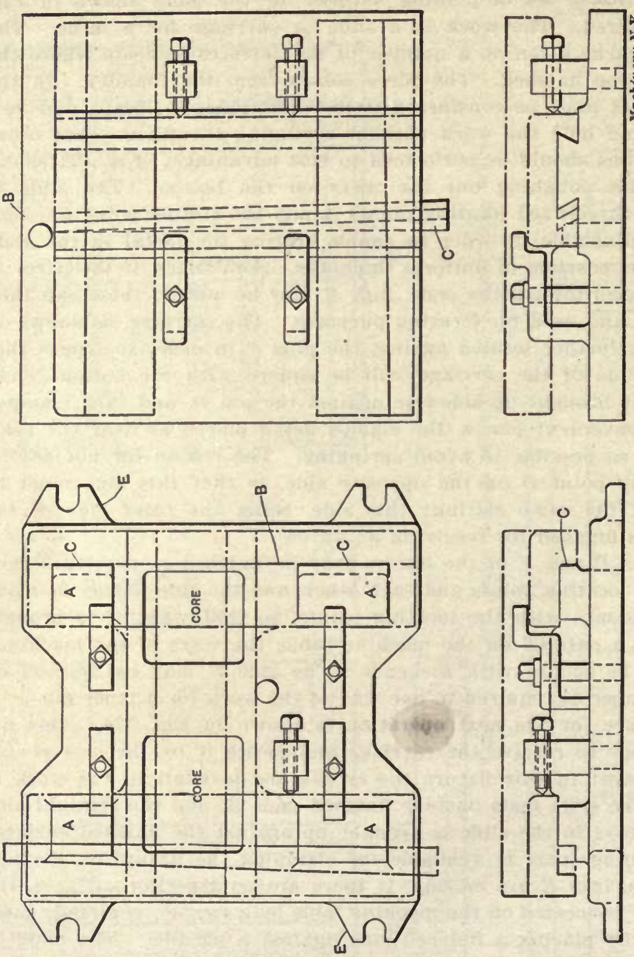
The sides *E* and *F* of the fixture may be finished in a certain relation to the locating points and each other, and the side *E* may be made perfectly square with the locating points, so that when it is brought up against a parallel on the machine table, the ways of the machined piece will be square with the ends. The side *F* may be finished on the same taper as required in one way of the work for a taper gib.

The fixture for the next operation is shown in Fig. 174. This fixture is made to receive the carriage and locate it by the now rough-finished ways; in this fixture the cross-slide dove-tail in the work is planed. The slide rests on four finished pads *A*, and the straight side *B* of the ways in the slide is brought up against the finished surfaces *C*. If no other part is available for clamping the fixture on the machine table, lugs *E* are added. If there are no tapering surfaces, the fixture can be located on the machine table by a tongue, as already mentioned, or by placing a finished side against a parallel. The slide or dove-tail is now roughed out and it is usually sufficiently accurate practice to finish it in the same setting, especially as slides must always be scraped and fitted to suit the machine on which they are to be used.

The next operation would be performed in the fixture illustrated in Fig. 175. The carriage is here located by the dove-tail and by the pin *B*, and held by a gib *C*, or by straps and screws, as shown. It will be noticed that with the given design, the straps and screws must be

removed each time a new piece is inserted, which is an undesirable feature of the fixture. If parts *A* in Fig. 170 project out too far, so that a light finishing cut would cause springing, they are supported by sliding points or other adjustable locating means.

If the dove-tail in the slide had simply been rough-finished in the fixture Fig. 174, the finishing operation of the bottom ways could



Figs. 174 and 175. Fixtures for Planing the Dove-tail Slide and for Finish Planing the Ways of Carriage in Fig. 170

have been done as just described in the fixture in Fig. 175, and then, after having finished the bottom ways in this fixture, the work could again have been located in the fixture Fig. 174, and the dove-tail finished; this procedure might insure more accurate work in some cases.

In the case just described, the work requires three different fixtures to be completed. The number of fixtures to use in each case is entirely dependent upon the nature of the work. When there is a large amount

of work of the same kind to be done, several fixtures of the same type are made up for the same piece, and when in use these fixtures are placed in a "string" on the table of the machine, as shown in Fig. 172. Each strap holds down two of the jigs, one on each side of the bolt through the strap. The first one of the fixtures, *A*, is provided with a templet *B*, to which the tool may be set. The fixtures are located against the bars *C* and *D*, alternately, depending upon whether the straight or tapered side of the slide planed in these fixtures is being finished.

Templets are often made up separately and are used to determine the machining of both larger and smaller work. A templet may even be made adjustable, as shown in Fig. 176. This templet may be fastened to the machine table either in front or behind the work and the tool set to it, and is used when planing machine beds. Other templets or gages are made for testing the planing. They may not properly be considered as parts of the fixtures, but are usually designed and made at the same time as the fixtures are completed. These

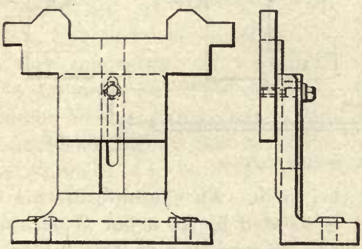


Fig. 176

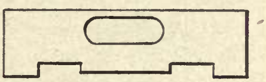


Fig. 177

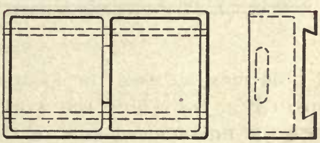


Fig. 178

Figs. 176 to 178. Gages for Setting Tools and Testing Work

gages are made from sheet iron, and the profile or cross-section of the work to be planed or milled is cut into the templet, as shown in Fig. 177. Other testing pieces may be made up more elaborately, as shown in Fig. 178. These latter are also used for testing when scraping and fitting the work. One templet may be made for rough planing or milling and one for the finishing cut.

A milling fixture of a type commonly used is illustrated in Fig. 179. The work *A* is supposed to be milled on both sides simultaneously. It is located on the fixture base *B*, and is held up against the half V-shaped piece *C*, which is stationary and held to the base by screws; the clamping is done by a clamp *D*, which is guided at *E* as indicated, so that it has a tendency to hold the work down well. Both the clamp and the corresponding piece *C* are thinner than the work, so as to allow the straddle milling cutters to pass over the fixture without interference.

In Fig. 180 is illustrated a simple fixture which may be used for both milling and planing. Two pieces are machined at the same setting in this fixture, and are located against the finished seats *A* and *B*. which latter acts both as a seat and as a stop. Another seat like *B* on the opposite side is not visible in the illustration. As the work to

be done is of a rough character, sliding points provided at *C* give an adjustable support. The work is clamped by the pointed screws *D*. The tool is set by the lug *E*, which is cast solid with the fixture and which has its top finished to the required height.

It is often advantageous to perform milling operations after the boring and drilling has been done on the work, and then some fin-

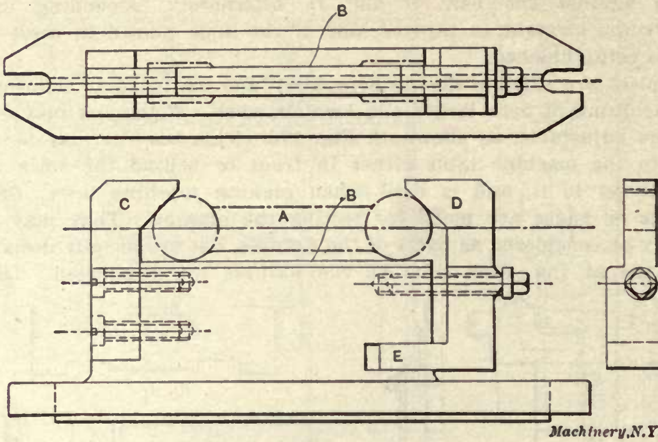


Fig. 179. A Typical Milling Fixture

ished hole may be used for locating the work. An example of this is shown in Fig. 181 where the work *A* is located by an arbor *B* passing through the finish-bored hole in the work, and resting on two V-blocks planed out in the fixture as shown. Two straps *C* hold the arbor down in the V-blocks. The work is further located against the screws *D*,

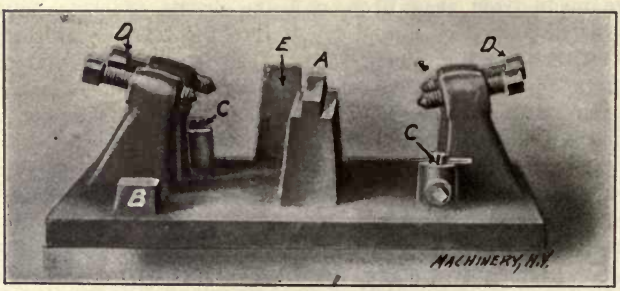


Fig. 180. Simple Type of Milling Fixture

which are adjustable so that the work may be held level. The clamping screw *E* holds the work against the screws *D*.

It is sometimes advantageous to make fixtures for holding work in the lathe. Suppose that a piece to be finished has the appearance shown in Fig. 182. The dove-tail *A* is finished, and the circular seat *B* is to be turned afterward so that the center of the seat will come in a certain relation to the dove-tail and a certain distance from the end. This operation can be carried out as shown in Fig. 183, by plac-

ing parallels *A* on the face-plate *B* of the lathe. These parallels will serve as locating means, and straps *C* hold down the work. If it is required that the seat be in exact relation to the dove-tail, two rollers *D* may be used against which the slide is located; the angle of the dove-tail and the diameter of the rollers are calculated so that the work can be very carefully located.

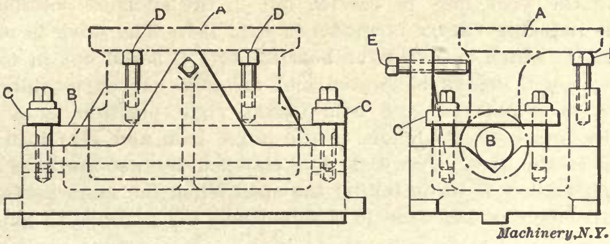
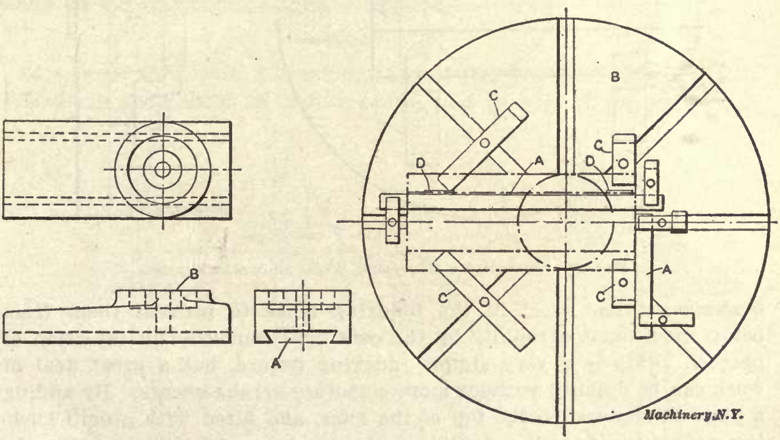


Fig. 181. Milling Fixture in which Work is Located from a Previously Bored Hole

The work may be turned out properly by this means by a careful man, but there are always chances of moving the parallels and it is a slow operation. If a simple fixture like the one illustrated in Fig. 184 is used, an apprentice can do the work correctly, provided he knows how to run a lathe. The work *A* is located by a dove-tail in a manner similar to that in which it will later be located on the machine on which it is to be used. It is held against the dove-tail in the fixture



Figs. 182 and 183. Work to be Recessed and Faced, and Method of Doing it in a Lathe

by screws *B* and clamped down on its seat by straps *C*. The pin *D* locates the work in the other direction, and the fixture itself is located on the face-plate by the boss *E*; as this boss has a perfect fit in a recess turned out in the face-plate, it must, by necessity, run true. Slots may be provided for locating the fixture on the face-plate and driving keys inserted at *F*. A sufficiently large lug *G* may be provided for counter-balancing.

It is always of advantage to try to locate work in fixtures in the same manner as it is located on the machine in which it is to be used

Indexing Fixtures

A number of fixtures for performing various operations are fitted with indexing devices, so that accurate machining at predetermined places in the work may be carried out in the shortest possible time. A simple indexing fixture is shown in Fig. 185. The work is mounted on a disk *A*, which turns in the bearing hole *B* bored out in the knee or angle iron *C*, which is located and fastened on the machine table. The disk *A* is indexed, and held in the right position by a pin *D*, which fits into a finished hole in the angle iron and also into one of the holes in the disk. The disk *A* is clamped against the knee *C* by a screw and washer *E* while taking the cut. When the main parts of this fixture are made of cast iron it is sometimes the practice to put lining

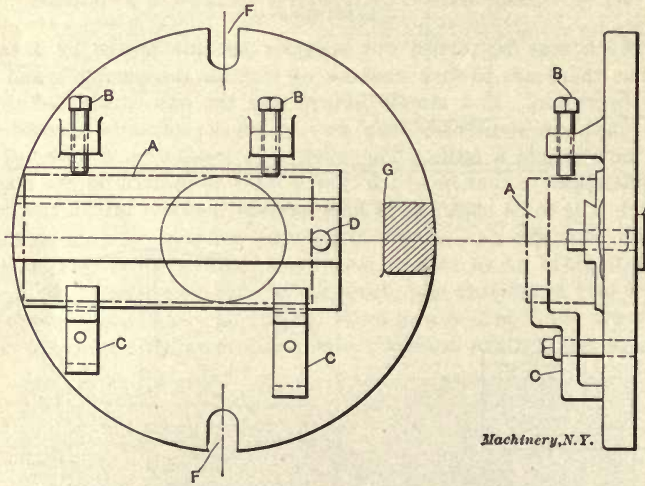


Fig. 184. Fixture for Recessing Work shown in Fig. 182

bushings of tool steel in the indexing holes to prevent them from being worn out too rapidly by the continual removal and insertion of plug *D*. This is a very simple indexing fixture, but a great deal of work can be finished without more elaborate arrangements. By adding a plate *F*, screwed to the top of the knee, and fitted with a drill bushing as indicated, radial drilling operations may be performed in the same device.

In Fig. 186 is shown a similar indexing fixture somewhat modified. The work is located and held on the rotating disk *A*, which is fitted in place in the bracket or body *C*, so as to have no play. The round plunger *B* is beveled on the end, and fits the slots in the circumference of the disk. A spiral spring pushes the plunger into place. The plunger is guided by a pin in an oblong slot, so as not to turn around. Sometimes the plunger may be made square or with a rectangular

section, and fit a slot which may be shaped to this form. This latter method is more expensive and does not give better satisfaction than the plunger with the round body.

A large variation of methods for indexing are in use, employing pawls, levers, springs and safety-locking devices, which sometimes may be necessary. Indexing fixtures, however, designed according to the

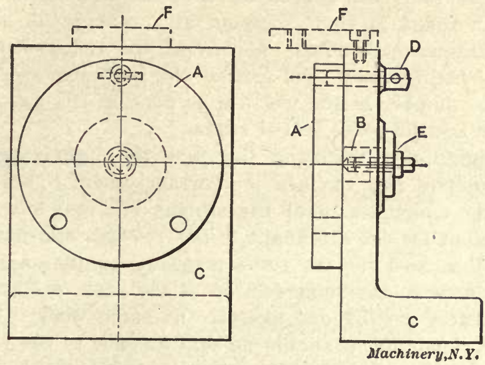


Fig. 185. Simple Type of Indexing Fixture

simple principles laid down above, will give as good service as many complicated arrangements. These indexing devices are used in cases where the standard indexing heads would not be suitable, and for many classes of work are equally efficient.

Conclusion

In a large shop with a great number of jigs and fixtures, it is quite difficult to keep them in proper order, and to have them so indexed

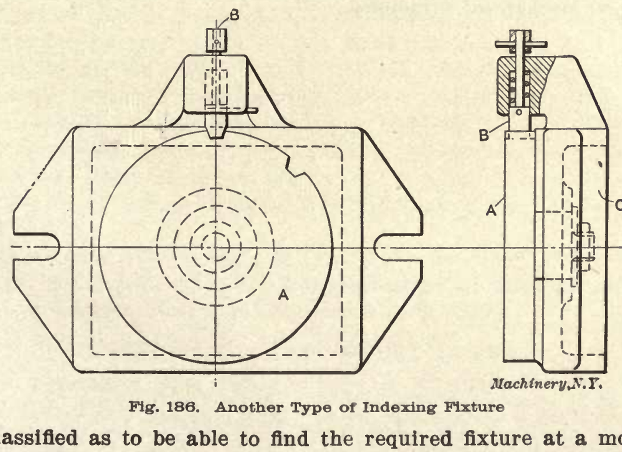


Fig. 186. Another Type of Indexing Fixture

and classified as to be able to find the required fixture at a moment's notice. It is unquestionably the best way to permit each department to have a storing place for all its own jigs and fixtures, more especially so if there is a store-room for other tools in each department. The jigs or fixtures are given out to the operators in exchange for

checks, and before they are returned they should be carefully cleaned and the finished surfaces greased to prevent rusting. Before returning the check to the workman, the tool-room clerk should look over the fixture to see that no loose parts are missing, and no parts broken, and also that all loose pieces are tied together and attached to the jig body. The tools are placed on shelves partitioned off and numbered and an index is kept, showing at a glance the location of the tools for different operations. A copy of the index should be in the possession of the foreman, and also of the tool-room clerk, and should give the piece number of the work to be done in the jig, the number of the jig itself, and its place in the racks.

When arranging and storing the jigs, the lighter jigs are placed on the top shelves and the heavier further down. This not only permits a lighter construction of the storing shelves, but also makes it more convenient for the attendant to put the jigs and fixtures in place. If possible, jigs used for the same machine, or the same type of machines, should be in the same section of the rack, as this, to a certain extent, facilitates getting out jigs for the same work. When a jig or fixture needs repairing, it should be sent at once to the tool-making department, even if it is not to be used immediately.

In some trade journals there has been a great deal of paper wasted discussing what position a tool and jig designer really occupies,—whether he should be considered a designer with a designer's salary, or simply a draftsman, and of other topics of similar nature. The fact remains, however, that a progressive manufacturing plant, in order to have suitable and efficient tools devised, requires a man who possesses in the first place, good shop experience, in the second place, sound practical judgment, and in the third place, a fundamental knowledge of theoretical mechanical principles.

(See back cover for additional titles)

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